MCDONNELL DOUGLAS

SPACE TUG SYSTEMS STUDY (CRYOGENIC) SEPTEMBER DATA DUMP

VOLUME 4 Mission Accomplishment Book 1 Option 1

SEPTEMBER 1973

PREPARED BY: SPACE TUG STUDY TEAM

APPROVED BY: L. Q. Westmoreland

L. Q. WESTMORELAND
STUDY MANAGER

(NASA-CR-179109) SPACE TUG SYSTEMS STUDY (CRYOGENIC) SEPTEMBER DATA DUMP. VOLUME 4: MISSION ACCOMPLISHMENT. BOOK 1: OPTION 1 (McDonnell-Douglas Astronautics Co.) 252 p
Avail: NTIS

N87-70392

Unclas
00/18 0072748

PREPARED FOR NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MARSHALL SPACE FLIGHT CENTER
UNDER CONTRACT NO. NAS8-29677

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY-WEST
5301 Bolsa Avenue, Huntington Beach, CA 92647

PREFACE

This study report for the Tug Program is submitted by the McDonnell Douglas Astronautics Company (MDAC) to the Government in partial response to Contract Number NAS8-29677.

The current results of this study contract are reported in eight volumes:

Volume 1 – Summary, Program Option 1
Volume 2 – Summary, Program Option 2
Volume 3 – Summary, Program Option 3

These three summary volumes present the highlights of the comprehensive data base generated by MDAC for evaluating each of the three program options. Each volume summarizes the applicable option configuration definition, Tug performance and capabilities, orbital and ground operations, programmatic and cost considerations, and sensitivity studies. The material contained in these three volumes is further summarized in the Data Dump Overview Briefing Manual.

Volume 4 – Mission Accomplishment. (3 Books and 1 Supplement Bound Together)

This volume contains mission accomplishment analysis for each of the three program options and includes the tug system performance, mission capture, and fleet size analysis.

Volume 5 – Systems (3 Books)

This volume presents the indepth design, analysis, trade study, and sensitivity technical data for each of the configuration options and each of the Tug systems i.e., structures, thermal, avionics, and propulsion. Interface with the Shuttle and Tug payloads for each of the three options is defined.

Volume 6 – Operations (3 Books)

This volume presents the results of orbital and ground operations trades and optimization studies for each option in the form of operations descriptions, time lines, support requirements (GSE, manpower, networks, etc.), and resultant costs.

Volume 7 – Safety (3 Books)

This volume contains safety information and data for the Tug Program. Specific safety design criteria applicable to each option are determined and potential safety hazards common to all options are identified.

Volume 8 – Programmatics and Cost (3 Books)

This volume contains summary material on Tug Program manufacture, facilities, vehicle test, schedules, cost, project management SR&T, and risk assessment for each option studied.

These volumes contain the data required for the three options which were selected by the Government for this part of the study and are defined as:

A. Option 1 is a direct development program (I.O.C.: Dec 1979). It emphasizes low DDT&E cost; the deployment requirement is 3500 pounds into geosynchronous orbit, it does not have retrieval capability, and it is designed for a 36-hour mission. MDAC has also prepared data for an alternative to Option 1 which deviates from certain requirements to achieve the lowest practicable DDT&E cost.

B. Option 2 is also a direct development program (I.O.C.: 1983). It emphasizes total program cost effectiveness in addition to low DDT&E cost. The deployment requirement is 3500 pounds minimum into geosynchronous orbit and 3500 pounds minimum retrieval from geosynchronous orbit.

C. Option 3 is a phased development program (I.O.C.: 1979 phased to I.O.C. 1983). It emphasizes minimum initial DDT&E cost and low total program cost. The initial Tug capability will deploy a minimum of

3500 pounds into geosynchronous orbit without retrieval capability, however, through phased development, it will acquire the added capability to retrieve 2200 pounds from geosynchronous orbit. The impact of increasing the retrieval capability to 3500 pounds is also provided.

INTRODUCTION

This volume contains the results of the mission accomplishment assessment analysis for program options 1, 2, and 3, the increased retrieval capability (called 3S), and the other sensitivity studies which impact mission accomplishment. The volume is divided into three books, one for each of the major options (1, 2, and 3), and a supplement for the increased retrieval version of option 3--identified as 3S. Sensitivity impacts are included with the option to which they are addressed. Each includes identification of vehicle concept and its related performance, a summary of the capture analysis and the flight by flight mission assignments.

The data presented in this volume conforms to the agreements and groundrules provided at the August 6, 1973 Mission Model Standardization Meeting at Denver, Colorado. The forms provided at that meeting and subsequently transmitted by NASA letter PD-TUG-E (74-49) are included in the data provided. To provide a complete compilation of the data, the Government provided mission model for each option is included.

The capture analysis was performed by selecting payloads for each Tug flight based upon the inherent performance capability of the Tug (payload weight vs. delta velocity, mission duration, maneuver, rendezvous and docking and multi-payload), the constraints of the Shuttle (payload weight vs. orbit and cargo bay physical dimension) and the characteristics of the payload (physical size, weight, Tug mission required). Payloads were combined to provide the least total flights to accomplish the mission model requirements.

GROUNDRULES

The Mission Capture Analysis was constrained by the ground rules provided by the Government and by the characteristics of each of the programs. The ground rules used were as follows:

1. All missions are to be accomplished for each configuration(s) in each option according to the deploy/retrieve schedule and payload weights specified in the Option Mission Model.

2. The additional payload capture potential for each configuration to perform those mission excluded from the Option Mission Model because of performance and/or Tug mission duration constraint assumed for the basic option will be assessed. This assessment is to identify the additional payload missions that could be performed, the Tug flight configuration and mode required, and the total number of payloads that could be accommodated.

3. DOD Mission 11 has been excluded from Option 1 because of the mission duration impact on the Tug.

4. DOD Mission 12 is defined as a sortie mission having a nominal mission duration of seven days; however, for the capture analysis it is to be assumed that the mission duration inherent in the Tug configuration for the Option being considered is sufficient; therefore mission duration is not be be considered in determining the capture potential of this mission but performance capability only.

5. DOD Mission 12b weight is to be assumed fixed at 2400, and not "rubber" as footnoted in Table A-3 of the DOD Mission Model Annex.

6. The current design weight is to be assumed for all planetary deployments in the basic option mission models.

7. For Option 1 the Tug provides no capability for longitudinal positioning of payloads after attaining sync orbit, but for Option 2 and 3 the Tug provides a one-time 60° longitude shift capability for multi-deploy missions. The payload is assumed to have on-board capability for any additional maneuvers required for final positioning (see previously provided Government Action Item for more detail).

8. NASA Geo Sync payloads may be combined for deployment up to a total of three payloads for a single Tug flight.

9. DOD 3a may be deployed as a single payload or as a two payload combination. The payload provides orbit positioning capability. Round-trip missions should assume 1 payload deployed/1 payload retrieved.

10. DOD 11 payloads provide orbit positioning.

11. NASA payloads 12-16 may be combined for deployment with the Tug providing the energy for orbit changes only with no requirement for payload positioning within the orbit.

12. Single payload retrieval missions are to be assumed in all cases.

13. Planetary payloads (NASA Missions 17 through 24) are always single deployment missions.

14. The contractor is to determine the most cost effective mode for mission accomplishment (i.e., expend vs. orbit assembly, etc.).

15. In Options 2 and 3 LCD and CD payload may be combined for deployment.

16. For configurations employing the "nudge" mode the DOD groundrule of <u>not</u> mixing payloads on a given flight is to be adhered to, i.e., only the same type payload may be deployed and "nudged" on the same flight.

17. The 300 watt power supply to the payload is not a requirement for Option 1, and for Options 2 and 3 it may be assumed that a total of 300 watts is constant and continuous until the last payload is deployed and is not a function of the number of payload in a multi-deploy mission.

18. Payloads may be physically combined in any orientation such that the Shuttle cargo bay boundaries (15' x 60') are not violated.

CONTENTS

Section 1

PERFORMANCE

1.1 PERFORMANCE GROUND RULES

The payload performance was determined using the classical impulsive velocity equation. The velocities employed were based on the three dimensional finite burning trajectory analyses performed during Task 1. A detailed simulation of the basic geosynchronous deployment mission taking into account the actual losses associated with each engine start and the velocity contributed by propellant settling forces was used to determine an equivalent specific impulse penalty of 4 seconds which was then used for all missions.

For the geosynchronous transfer, a velocity of 13972 fps was used which represents the most unfavorable situation (from a performance point of view) of no low orbit phasing being required and the resulting injection to the transfer orbit being performed with only one burn instead of two. This velocity is approximately 80 fps greater than the most favorable two burn transfer injection. The 36 hour maximum mission duration for this option does not permit the long phasing required to reach particular longitudes with the two burn departure. For the return, a velocity of 13920 fps was used.

The following weights and engine data were also employed in the performance computations:

Shuttle Capability	65,000
Ancillary equipment (to install Tug in the Orbiter Bay)	2,066
Vented during ascent	269
Tug gross weight at deployment from Orbiter Bay	62,665
Tug burnout weight (includes FPR)	7,340
Propellant capacity (@5.5 EMR)	51,000

Engine chilldown (each start)	61
Vented in flight	57
Attitude control propellant	93
Propellant settling	160
Engine	Category I RL-10
Thrust	15,000
Isp (@ 5.5EMR)	441.8

1.2 GEOSYNCHRONOUS PERFORMANCE

Based on the foregoing ground rules and data, it was determined that Option 1 could deploy 3521 lb to a geosynchronous orbit. This option has no requirement for retrieval capability, consequently the tankage was sized for the deployment missions. As a result, the propellant tanks rather than Shuttle delivery (and consequently Tug gross weight) become the limiting factor in round trip mission performance. The resultant round trip payload capability is 993 lb. It must be pointed out that this round trip mission involves carrying a single payload to synchronous orbit and returning with it rather than delivering one payload and retrieving of a second of equivalent weight. Figure 1.2-1 shows how the payload delivery capability decreases as payload is returned.

1.3 PERFORMANCE ENVELOPE - PAYLOAD WEIGHT vs.Δ VELOCITY

Figure 1.3-1 presents the payload velocity envelope for the mission modes applicable to Option 1 for due east Shuttle launches. The following figures show the same data for Shuttle launches into 55° and polar inclinations. These data reflect the 4 second Isp penalty for stop/start losses, boiloff and attitude control propellants. For missions where the Tug would be less than fully loaded, it would be advantageous to off load LOX only initially to reduce the engine mixture ratio and improve Isp by up to 4 seconds at the limiting EMR of 4.5:1.

1.4 PERFORMANCE SENSITIVITIES

1.4.1 General Mission Trade Factors

The sensitivity of payload to the two principle performance factors, -Tug inert weight and Isp - are presented as a function of mission velocity in Figure 1.4-1.

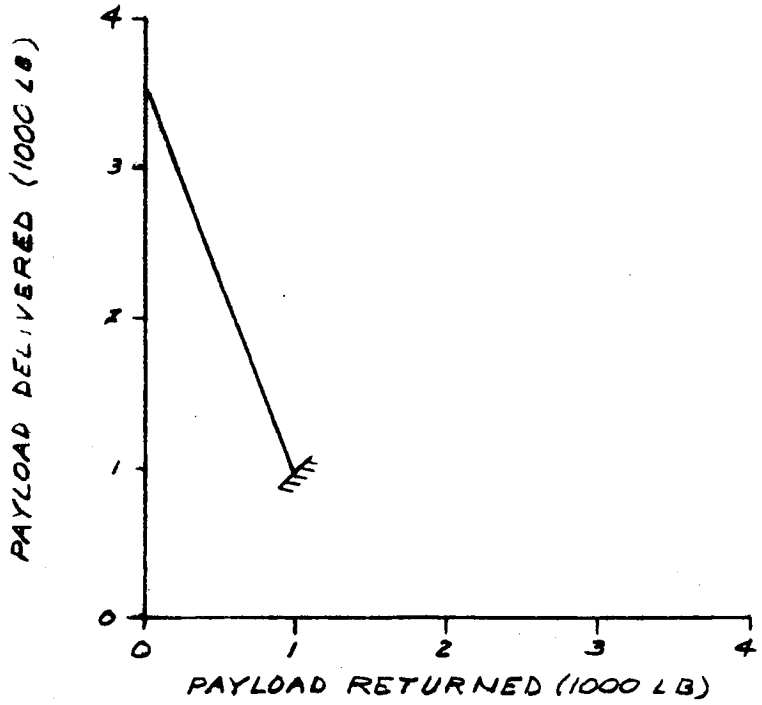
DOUGLAS

PREPARED BY: S.P.T. MODEL
REFERENCE
REPORT NO. REVISED
PAGE NO. DATE: 9/6/73

GEOSYNCHRONOUS PERFORMANCE

CONFIGURATION OPTION 1

NOTE: PAYLOAD RETURNED IS INCLUDED AS PART OF PAYLOAD DELIVERED.



DOUGLAS

PERFORMANCE SENSITIVITY

CONFIGURATION OPTION I

REVISED _____

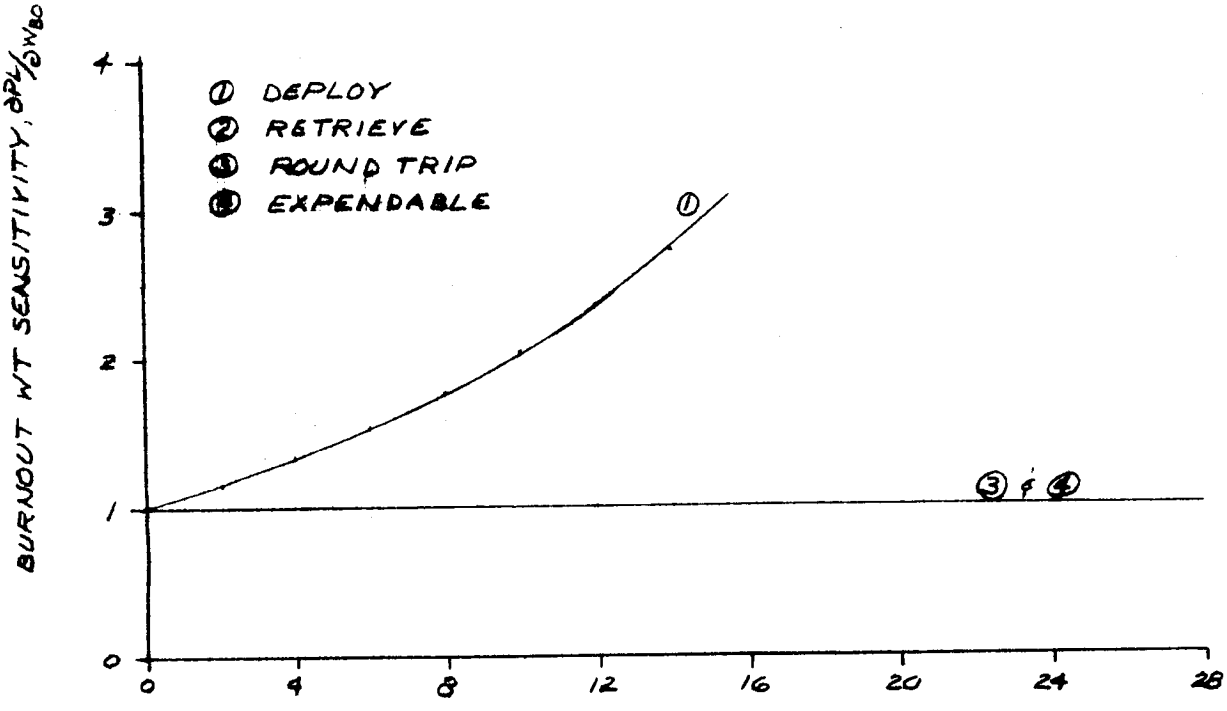
REPORT NO. _____ DATE _____

PAGE NO. _____

MODEL _____

PREPARED BY: _____

REFERENCE _____



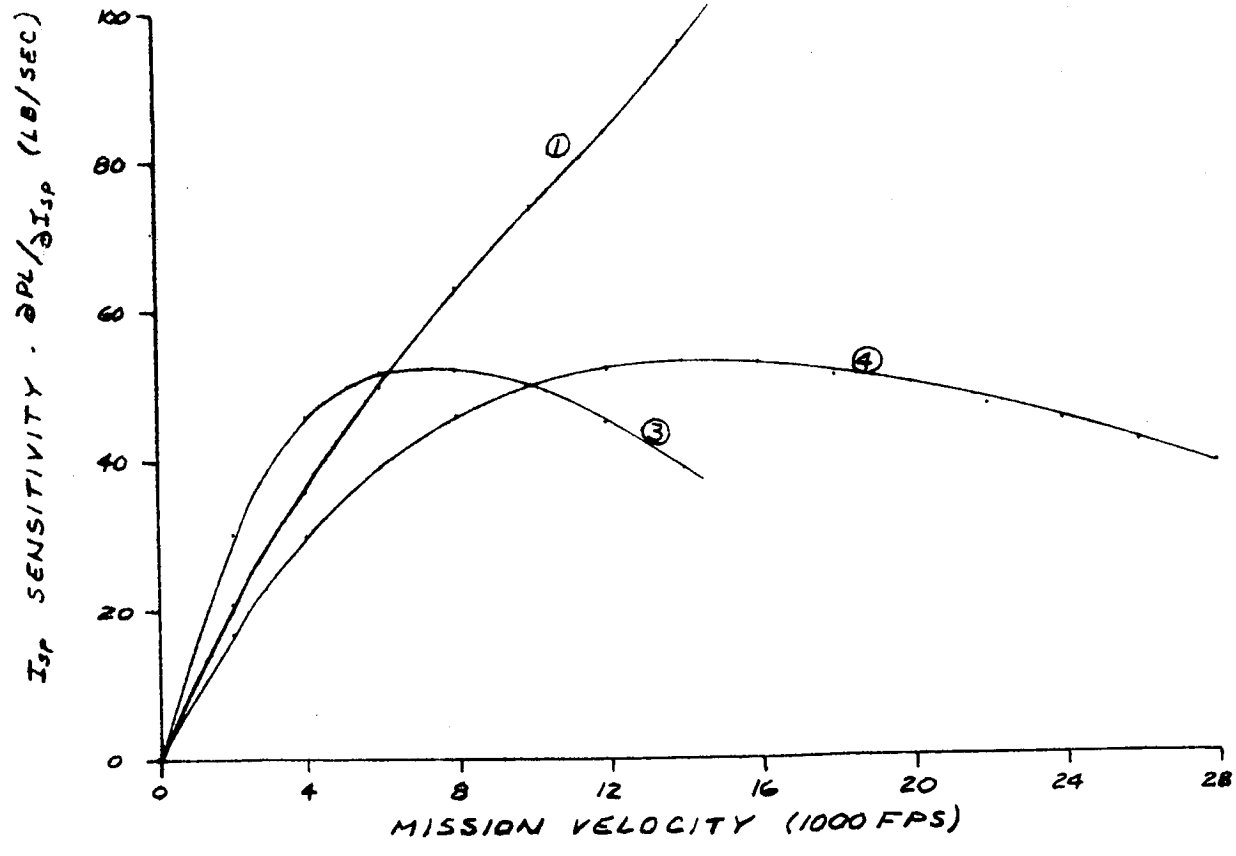


FIGURE 1.3-1

PERFORMANCE CAPABILITY

CONFIGURATION OPT 1

W_{BO} 7340

I_{SP} 441.8

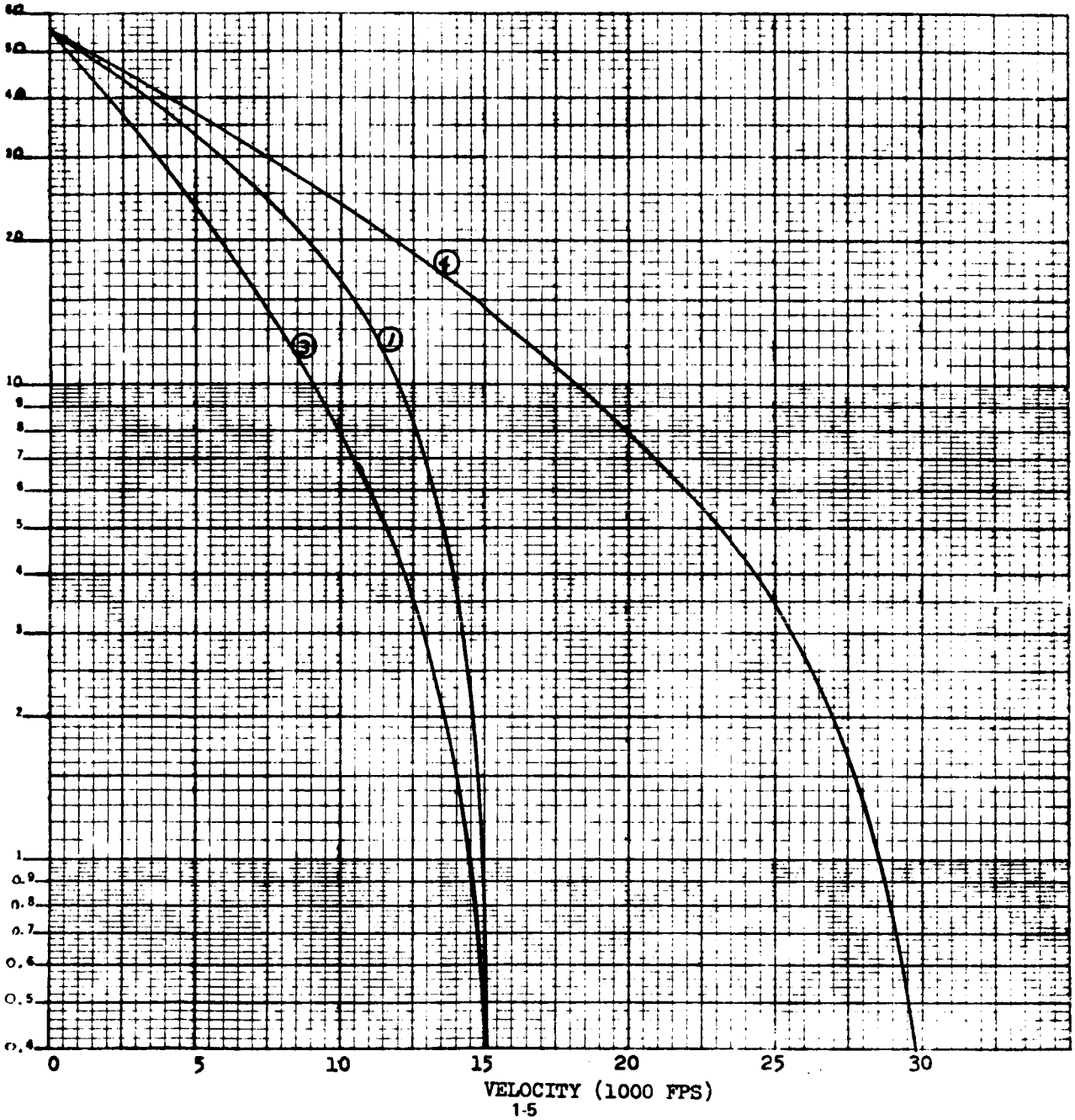
INCL 28.5°

① DEPLOY

② RETRIEVE

③ ROUND TRIP

④ EXPENDABLE



PERFORMANCE CAPABILITY

CONFIGURATION OPT 1

W_{BO} 7340

I_{SP} 441.8

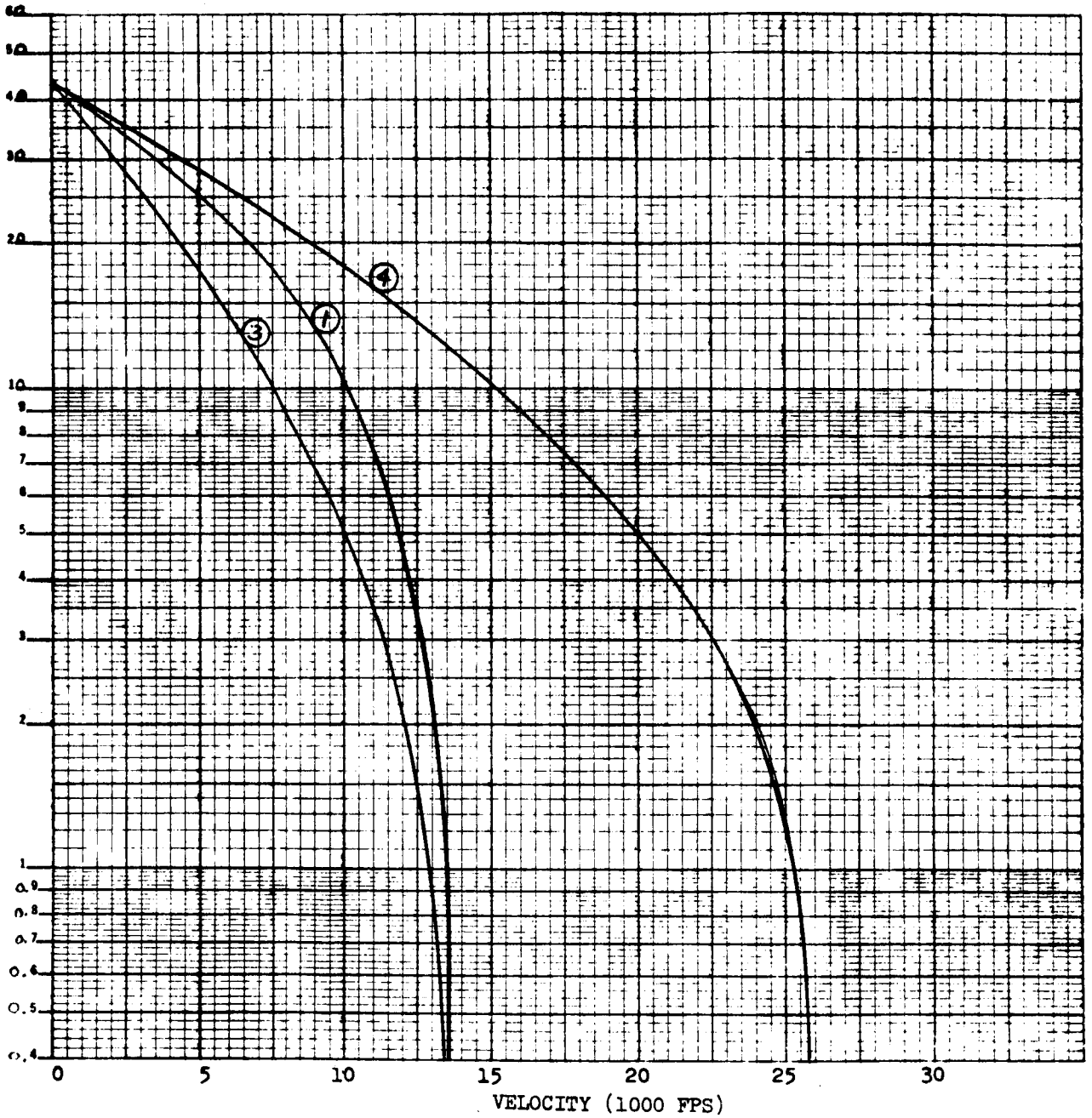
INCL 55°

① DEPLOY

② RETRIEVE

③ ROUND TRIP

④ EXPENDABLE



PERFORMANCE CAPABILITY

CONFIGURATION OPT I

W_{BO} 7340

I_{SP} 441.8

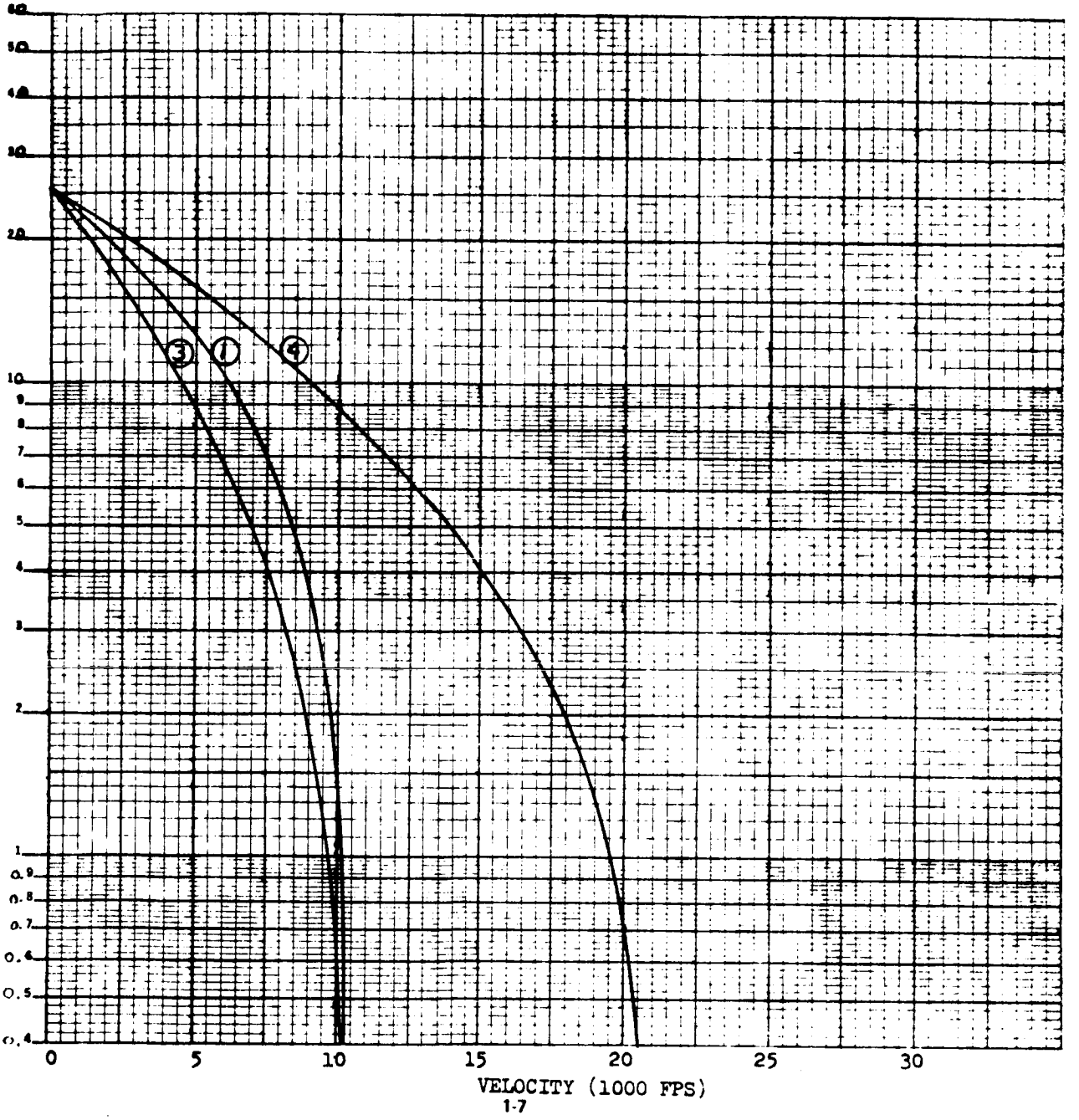
INCL 90°

① DEPLOY

② RETRIEVE

③ ROUND TRIP

④ EXPENDABLE



1.4.2 Geosynchronous Trade Factors

Specific trade factors for the geosynchronous missions are given in Table 1.4-1. The inert weight factor is applicable to any weight carried throughout the mission, such as structure and residual propellants. The gross weight factor can correct for variations in the Tug gross weight at first ignition such as Shuttle capability, ancillary equipment or propellants vented during ascent.

1.5 MISSION PERFORMANCE

The performance capability for each mission in the mission model was computed for each basic mission mode. The missions are defined in Table 1.5-1. Table 1.5-2 is a computer printout of the results and includes the velocities derived from Task I. The gross weight reflects the Shuttle delivery capability to the appropriate parking orbit inclinations. In several cases, alternate mission profiles are shown starting from different inclinations.

For the Option 1 vehicle, retrieval capabilities are shown even though the equipment necessary to physically pick up or attach such a payload is not included in the Tug weight shown. The capabilities with a kick stage were also determined for use in the mission capture analysis but are not shown simply to avoid classifying any data.

Several missions with gross weights of 62,665 show payloads below the nominal geosynchronous deployment capability of 3,932. For these specific missions, the propellant burned would exceed the capacity of the tanks. The following formula should be used to provide an approximate corrected payload reflecting the propellant tank limitations:

$$PL_{Corrected} = PL_{Shown} - (3{,}932 - PL_{Shown}) \frac{\partial PL}{\partial w_o}.$$

Table 1.4-1

GEOSYNCHRONOUS MISSION TRADE FACTORS

	DEPLOY	ROUND TRIP
Burnout Weight: $\partial PL / \partial W_{BO}$	-2.67	-1
Specific Impulse: $\partial PL / \partial I_{sp}$	95	39
Gross Weight: $\partial PL / \partial W_{o}$	.37	.14
Orbit Losses: $\partial PL / \partial W_{OL}$	-1	-.37

Table 1.5-1

MISSION DESCRIPTIONS

Mission No.	H_a x H_p (nmi)	Incl.	Remarks
1-8	19323	0	Synchronous orbit - single burn transfer orbit injection
1-8A	19323	0	Synchronous orbit - two burn transfer injection
1-8B	19323	0	Synchronous orbit - two burn transfer injection with 600 fps for multiple payload deployments
9	1AU	Eclip.	
10	6900	55°	
10A	6900	55°	Alternate - Shuttle launched into 28.5°
11	16Kx30K	20°	
12	180x1800	90°	
13	1Kx20K	90°	
13A	1Kx20K	90°	ETR Alternate - Shuttle launched into 28.5°
13B	1Kx20K	90°	ETR Alternate - Shuttle launched into 55°
14	300x3000	90°	
15	700	100°	
16	500	99.2°	
17-8	Interplanetary		ΔV - 13000
19			16500
20			23000
21-2			24000
23			18400
24			22000
D11	58K	0,30,60	
D10	860x21K	63.4	Shuttle launch into 63.4° WTR
D10A	860x21K	63.4	ETR Alternate - Shuttle launched into 55°
D5	750	99°	
D3	13.6Kx25K	60°	Shuttle launched into 60° WTR
D3A	13.6x25K	60°	ETR Alternate - Shuttle launched into 55°
D12	300	104°	
D16	400	98.3°	

CØNFIGURATIØN ØPT 1 STAGE WT=7340.00 ISP=441.80 DELISP=4.00

MISSIØN	GRØSS-WT V-ØUT	PL-RØUND V-BACK	PL-DEPLØY	PL-RETRIEVE	PL-EXPEND
1-8	62665.00 13972.00	993.00 13920.00	3521.35	2087.99	15900.11
1-8A	62665.00 13890.00	1361.27 13920.00	3657.04	2168.44	16035.79
1-8B	62665.00 14190.00	998.42 14220.00	2739.99	1570.82	15543.22
9	62665.00 14160.00	939.44 14350.00	2602.03	1470.28	15592.01
10	50665.00 9700.00	5440.99 9700.00	10833.03	10931.39	18106.98
10A	62665.00 12760.00	2897.37 12760.00	7168.42	4862.89	17988.35
11	62665.00 12450.00	3358.05 12450.00	8127.34	5722.47	18551.96
12	32665.00 2285.00	16274.57 2285.00	19140.84	108681.37	20433.55
13	32665.00 8400.00	2570.66 8400.00	4666.97	5723.02	10652.55
13A	62665.00 13460.00	1928.80 13460.00	5015.20	3134.18	16760.40
13B	50665.00 11200.00	2989.24 11200.00	6620.35	5450.08	15536.43
14	32665.00 3600.00	12252.56 3600.00	15820.59	54327.76	17958.04
15	26665.00 1700.00	13606.58 1700.00	15351.94	119681.69	16293.46
16	26665.00 1120.00	15404.58 1120.00	16679.45	201542.69	17286.90
17-8	62665.00 13140.00	2284.20 13250.00	5851.40	3746.85	17314.18
19	62665.00 16740.00	.00 17210.00	.00	.00	11753.93
20	62665.00 23550.00	.00 24500.00	.00	.00	4434.11

21-2	62665.00 24600.00	.00 25500.00	.00	.00	3588.35
23	62665.00 18720.00	.00 19550.00	.00	.00	9250.04
24	62665.00 22500.00	.00 23500.00	.00	.00	5345.34
D11	62665.00 13930.00	1330.44 13930.00	3576.74	2118.43	15969.50
D10	48665.00 8500.00	7216.95 8500.00	13195.53	15928.77	19276.04
D10A	50665.00 9800.00	5260.80 9800.00	10548.90	10494.46	17926.97
D5	26665.00 1770.00	13399.42 1770.00	15193.52	113474.25	16176.30
D3	48665.00 11850.00	1706.80 11850.00	3958.64	3000.51	13642.44
D3A	50665.00 11920.00	1985.46 11920.00	4627.86	3477.30	14396.47
D12	26665.00 500.00	17497.61 500.00	18129.87	501743.19	18395.09
D16	26665.00 850.00	16293.48 850.00	17306.96	278240.25	17763.52

Section 2

CAPTURE ANALYSIS - OPTION 1

2.1 Flight Summary

The data provided in Section 2.1.1 represents a summary of the missions captured by the Option 1 program based upon all constraints of the system potential (Tug capability) and the program schedule (Tug and related support systems availability). Section 2.1.2 identifies the missions, from the Option Mission Model, which are not captured by the program and also includes the rationale for their exclusion.

2.1.1 Flight Summary Data

Tables 2-1 through 2-5 present the number of flights per year for each of the flight modes used in Option 1. Also shown are the total Shuttle and Tug flights and the number of missions identified as requirements in the Option Mission Model. On Table 2-1 the number of missions accomplished is identified.

The mission modes used in this option are defined as follows:

Deploy

Single Payload - The deployment of one payload to one location and velocity vector and return of the Tug to the Shuttle.

Multi - 2 Payloads - the deployment of two payloads to one location and velocity vector and return of the Tug to the Shuttle.

Multi - 3 Payloads - the deployment of three payloads to one location and velocity vector and return to the Shuttle.

Kick Stage - Large - the deployment of one or more payloads to one location and velocity vector using a Polaris kick stage as a second stage to the Tug. The kick stage is expended and the Tug returns to the Shuttle.

Expendable - the deployment of one payload to one location and velocity vector. The Tug is expended.

Round-Trip

Sortie - Carrying a payload to one orbital location remaining in that location for 22 hours and returning the Tug and the payload to the Shuttle.

FLIGHT SUMMARY—OPTION 1

Flight Mode		Calendar Year											Total
		80	81	82	83	84	85	86	87	88	89	90	
Totals	Shuttle	3	14	16	29	26	22	20	28	20	27	20	225
	Tug	3	14	16	29	26	22	20	28	20	27	20	225
Tug Flight Distribution	Deploy												
	Single Payload	2	9	9	15	15	13	7	13	12	13	10	118
	Multi--2 Payloads		1	4	10	6	4	6	9	5	7	7	59
	Multi--3 Payloads	1	4	1	3	1	4	3	2	3	3	2	27
	Kick-Stage - Large			2		2		3	2				9
	Expendable					2		1	1		3	1	8
	Retrieve												
	Round Trip												
	Sortie				1		1		1		1		4
Mission Model	Total												
	Deploy	25	23	24	45	34	34	32	41	31	40	31	360
	Retrieve	0	0	0	1	0	1	0	1	0	1	0	4
	Total	25	23	24	46	34	35	32	42	31	41	31	364
Accomplishment	Total	5	23	24	46	34	35	32	42	31	41	31	344

FLIGHT SUMMARY—NASA—OPTION 1

Flight Mode		Calendar Year											Total
		80	81	82	83	84	85	86	87	88	89	90	
Totals	Shuttle	3	8	8	14	14	12	10	16	9	17	9	120
	Tug	3	8	8	14	14	12	10	16	9	17	9	120
Tug Flight Distribution	Deploy												
	Single Payload	2	4	3	7	7	6	2	6	5	7	3	52
	Multi--2 Payloads			2	5	3	2	2	6	1	5	4	30
	Multi--3 Payloads	1	4	1	2		4	2	1	3	2	1	21
	Kick-Stage Mode			2		2		3	2				9
	Expendable					2		1	1		3	1	8
	Retrieve												
	Single Payload												
	Round Trip												
	Deploy 1/Retrieve 1												
	Deploy Multi/Retrieve 1												
	Sortie												
Mission Model	Total												
	Deploy	14	16	12	23	17	22	16	24	16	26	15	201
	Retrieve	0	0	0	0	0	0	0	0	0	0	0	0

FLIGHT SUMMARY—DOD—OPTION 1

Flight Mode		Calendar Year											Total
		80	81	82	83	84	85	86	87	88	89	90	
Totals	Shuttle	0	6	9	15	12	10	10	12	11	10	11	106
	Tug	0	6	9	15	12	10	10	12	11	10	11	106
Tug Flight Distribution	Deploy												
	Single Payload		5	6	8	8	7	5	7	7	6	7	66
	Multi--2 Payloads		1	3	5	3	2	4	3	4	2	3	30
	Multi--3 Payloads				1	1		1	1		1	1	6
	Kick-Stage Mode												
	Expendable												
	Retrieve												
	Single Payload												
	Round Trip												
	Deploy 1/Retrieve 1												
	Deploy Multi/Retrieve 1												
	Sortie				1		1		1		1		4
Mission Model	Total												
	Deploy	11	7	12	22	17	12	16	17	15	14	16	159
	Retrieve	0	0	0	1	0	1	0	1	0	1	0	4

FLIGHT SUMMARY—ETR—OPTION 1

Flight Mode		Calendar Year											Total
		80	81	82	83	84	85	86	87	88	89	90	
Totals	Shuttle	3	14	16	22	24	17	17	24	18	20	18	193
	Tug	3	14	16	22	24	17	17	24	18	20	18	193
Tug Flight Distribution	Deploy												
	Single Payload	2	9	9	15	15	13	7	13	12	13	10	118
	Multi--2 Payloads		1	4	7	5	2	4	7	3	4	6	43
	Multi--3 Payloads	1	4	1			2	2	1	3		1	15
	Kick-Stage Mode			2		2		3	2				9
	Expendable					2		1	1		3	1	8
	Retrieve												
	Single Payload												
	Round Trip												
	Deploy 1/Retrieve 1												
	Deploy Multi/Retrieve 1												
	Sortie												
Mission Model	Total												
	Deploy	25	23	24	29	29	23	25	33	27	24	26	288
	Retrieve	0	0	0	0	0	0	0	0	0	0	0	0

FLIGHT SUMMARY—WTR—OPTION 1

Flight Mode		Calendar Year											Total
		80	81	82	83	84	85	86	87	88	89	90	
Totals	Shuttle	0	0	0	7	2	5	3	4	2	7	2	32
	Tug	0	0	0	7	2	5	3	4	2	7	2	32
Tug Flight Distribution	Deploy												
	Single Payload												
	Multi--2 Payloads				3	1	2	2	2	2	3	1	16
	Multi--3 Payloads				3	1	2	1	1		3	1	12
	Kick-Stage Mode												
	Expendable												
	Retrieve												
	Single Payload												
	Round Trip												
	Deploy 1/Retrieve 1												
	Deploy Multi/Retrieve 1												
	Sortie				1		1		1		1		4
Mission Model	Total												
	Deploy	0	0	0	16	5	11	7	8	4	16	5	72
	Retrieve	0	0	0	1	0	1	0	1	0	1	0	4

2.1.2 Missions Not Captured

The availability of the Shuttle in 1980 limits Tug flights to 3. With this constraint the payloads selected for these flights were based upon the following rationale:

1. The first flight would be a simple flight with a light payload (although large enough to warrant use of the STS). NASA Mission 4 was selected.
2. The second flight would be a simple flight with a heavy payload. NASA Mission 8 was selected.
3. The third flight would add the complexity of multi-payloads (note that for Option 1 no orbit maneuvering is required for the placement of multiple payloads). NASA Mission 3 and 2 payloads of Mission 1 were selected.

The following missions were not performed in 1980:

NASA		DOD	
MISSION	NUMBER OF PAYLOADS	MISSION	NUMBER OF PAYLOADS
2	1	2	2
3	2	3b	1
6	1	15	1
7	1	3a	4
8	1	4b	1
9	1	8	2
11	1		
17	1		

All other missions both NASA and DOD were performed as required

2.2 Additional Payload Capture

The capability of the Option 1 Tug to capture missions beyond the Option 1 mission model is illustrated in Table 2-6 which indicates the mode in which the Option 1 Tug can capture various missions. The missions identified are those which are contained in the total mission model but are excluded in the Option 1 mission model.

NASA Missions 9, 17, and 18 can be flown in the normal Tug single payload deployment mode. NASA Missions 19, 23 and 24 can be flown by normal expendable Tug mode. NASA Mission 20 can be flown in the normal kick stage mode (with a Polaris kick stage).

NASA Mission 22 can be performed in a mode where both the kick stage (a Polaris) and the Tug are expended.

DOD Missions 11a, 11b, and 11c are eliminated from normal mode operation since transfer orbit periods (about 40 hours) are beyond the Option 1 duration capability. The mission can be performed, however, by using an injection kick stage and flying the Tug on a flight path similar to interplanetary mission flights. After burn into the transfer orbit the Tug separates retro-burns and returns to the Shuttle. The kick stage and payload coast to 58,000 n.mi where the kick stage provides the velocity to correct the velocity vector for proper orbital conditions.

DOD Mission 12b cannot be performed by the Option 1 Tug due to payload round-trip weight capability being less than 2400 pounds.

TABLE 2-6

OPTION 1

ADDITIONAL PAYLOAD CAPTURE POTENTIAL

MISSIONS EXCLUDED FROM OPTION MISSION MODE					CANDIDATE CONFIGURATION 1		
DESIGNATION		DEPLOY	RETRIEVE	SORTIE	TUG MODE		
I.D. #	WT				DEPLOY	RETRIEVE	SORTIE
N 9	1400	8	-	-	Normal 8	-	-
N 17	2000	3	-	-	Normal 3	-	-
N 18	3300	2	-	-	Normal 2	-	-
N 19	7900	3	-	-	Expendable 3	-	-
N 20	1500	4	-	-	Kick Stage 4	-	-
N 22	4000	4	-	-	Expend/ Kick Stage 4	-	-
N 23	6600	2	-	-	Expendable 2	-	-
N 24	4400	4	-	-	Expendable 4	-	-
D 12b	2400	-	-	5	-	-	-
D 11a	850	9	-	-	Kick Stage 9	-	-
D 11b	850	9	-	-	Kick Stage 9	-	-
D 11c	850	9	-	-	Kick Stage 9	-	-
TOTAL	DEPLOY	57	-	-	57	-	-
	RETRIEVE	-	-	-	-	-	-
	SORTIE	-	-	5	-	-	-
	TOTAL	62			57		

N = NASA D = DOD

2.3 FLIGHT DATA

2.3.1 Flight-by-Flight Mission Assignments

The following table (Tables 2-6) present the flight by flight mission assignments for each of the Tug flights for each year of the program. ETR and WTR launches are shown on separate pages.

Each chart shows the following data:

Flight Number - numbering of flights which is arbitrary and has no relation flight sequence or schedule.

Orbit - Mission orbit defined by altitude and inclination. In the case of interplanetary missions the mission velocity is given.

Flight Mode - the flight mode the Tug will operate to perform the mission. Flight modes used by the Option 1 Tug are defined as follows:

A	single payload deployment
A( )	multi-payload deployment
A-KL	payload deployment using kick stage (planetary mission)
A-E	payload deployment expending the Tug (planetary mission)

TABLE 2-6
MISSION CAPTURE
OPTION 1

LAUNCH SITE : ETR YEAR 1980

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	A	4	1500	—	—
2	SYNC. EQ	A	8	3500	—	—
3	SYNC. EQ	A(3)	3 1,1	2100	—	—
DOD FLIGHTS						
NONE						

MISSION CAPTURE
OPTION 1

LAUNCH SITE ETR YEAR 1981

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	A	B	3500	–	–
2	"	A	7	3000	–	–
3	"	A(3)	4,1,1	2500	–	–
4	"	A(3)	3,3,3	3300	–	–
5	"	A(3)	3,3,3	3300	–	–
6	"	A(3)	3,2,2	2700	–	–
7	6900 / 55°	A	10	6000	–	–
8	30x16K / 29	A	11	800	–	–
DOD FLIGHTS						
1		A	4a	3480	–	–
2		A	4a	3480	–	–
3		A(2)	2,2	1380	–	–
4		A	10	2745	–	–
5		A	B	2430	–	–
6		A	B	2430	–	–

MISSION CAPTURE
OPTION 1

LAUNCH SITE ETR YEAR 1982

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	A	8	3500	-	-
2	"	A	7	3000	-	-
3	"	A(2)	7,1	3500	-	-
4	"	A(2)	6,1	3100	-	-
5	"	A(3)	3,3,3	3300	-	-
6	1 A.U.	A	9	750	-	-
7	23000 fps	A-KL	20	900	-	-
8	23000 fps	A-KL	20	900	-	-
DOD FLIGHTS						
1		A	15	1970	-	-
2		A	3b	1570	-	-
3		A(2)	2,2	1380	-	-
4		A	4b	3480	-	-
5		A	4b	3480	-	-
6		A	8	2430	-	-
7		A	8	2430	-	-
8		A(2)	3a, 3a	3140	-	-
9		A(2)	3a, 3a	3140	-	-

MISSION CAPTURE
OPTION 1

LAUNCH SITE ETR YEAR 1983

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	A	B	3500	-	-
2	"	A	B	3500	-	-
3	"	A(2)	7, 1	3500	-	-
4	"	A	7	3000	-	-
5	"	A(2)	5, 2	2600	-	-
6	"	A	5	1800	-	-
7	"	A	5	1800	-	-
8	"	A(2)	3, 4	2600	-	-
9	"	A(2)	3, 3	2200	-	-
10	"	A	4	1500	-	-
11	30K x 16K/29	A	11	800	-	-
DOD FLIGHTS						
1		A	17	2220	-	-
2		A	17	2220	-	-
3		A	15	1970	-	-
4		A	3b	1570	-	-
5		A(2)	2, 2	1380	-	-
6		A	10	2745	-	-
7		A	4b	3480	-	-
8		A	B	2430	-	-
9		A	B	2430	-	-
10		A(2)	3a, 3a	3140	-	-
11		A(2)	3a, 3a	3140	-	-

MISSION CAPTURE
OPTION 1

LAUNCH SITE WTR YEAR 1983

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA - FLIGHTS						
1	500/99	A(3)	16,16,15	6200	-	-
2	"	A(2)	16,16	5200	-	-
3	VARIOUS LOW ORBITS	A(3)	12,13,14	2250	-	-
DOD FLIGHTS						
1		A(3)	5,5,5	2205	-	-
2		BA	12a	6000	12a	6000
3		A(2)	16,16	5220	-	-
4		A(2)	16,16	5220	-	-

MISSION CAPTURE
OPTION 1

LAUNCH SITE ETR YEAR 1984

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC EQ.	A	8	3500	-	-
2	"	A	8	3500	-	-
3	"	A	7	3000	-	-
4	"	A(2)	4, 1	2000	-	-
5	"	A (2)	3, 1	1600	-	-
6	1 A.U.	A	9	750	-	-
7	6900 / 55	A	10	6000	-	-
8	13000 fps	A	18	2000	-	-
9	"	A	18	2000	-	-
10	23000 fps	A-KL	20	900	-	-
11	"	A-KL	20	900	-	-
12	22000 fps	A-E	24	3300	-	-
13	"	A-E	24	3300	-	-
DOD FLIGHTS						
1		A	17	2220	-	-
2		A	17	2220	-	-
3		A	15	1970	-	-
4		A	4a	3480	-	-
5		A	4a	3480	-	-
6		A	3b	1570	-	-
7		A(2)	2, 2	1380	-	-
8		A	8	2430	-	-
9		A	8	2430	-	-
10		A(2)	3a, 3a	3140	-	-
11		A(2)	3a, 3a	3140	-	-

MISSION CAPTURE
OPTION 1

LAUNCH SITE WTR YEAR 1984

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	VARIOUS LOW ALT.	A(2)	14, 15	1400	—	—
DOD FLIGHTS						
1		A(3)	5,5,5	2205		

MISSION CAPTURE

OPTION 1

LAUNCH SITE ETR YEAR 1985

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	A	B	3500	-	-
2	"	A	B	3500	-	-
3	"	A	7	3000	-	-
4	"	A	7	3000	-	-
5	"	A	6	2600	-	-
6	"	A(2)	3,3	2200	-	-
7	"	A(3)	3,3,3	3300	-	-
8	"	A(3)	4,1,2	2800	-	-
9	30x110K/29	A	11	800	-	-
DOD FLIGHTS						
1		A	15	1970	-	-
2		A	6	3480	-	-
3		A	6	3480	-	-
4		A(2)	2,2	1380	-	-
5		A	4b	3480	-	-
6		A	4b	3480	-	-
7		A	8	2430	-	-
8		A	8	2430	-	-

MISSION CAPTURE
OPTION 1

LAUNCH SITE WTR YEAR 1985

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA - FLIGHTS						
1	VARIOUS LOW ALT	A(3)	12, 13, 14	2250	-	-
2	VARIOUS LOW ALT	A(3)	16, 16, 15	6200	-	-
3	500 / 99	A(2)	16, 16	5200	-	-
DOD FLIGHTS						
1		BA	12a	6000	12a	6000
2		A(2)	16, 16	5220	-	-

MISSION CAPTURE
OPTION 1

LAUNCH SITE ETR YEAR 1986

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	A	8	3500	-	-
2	"	A	8	3500	-	-
3	"	A(3)	3,3,3	3300	-	-
4	"	A(3)	3,3,1	2700	-	-
5	1 AU.	A(2)	9,9	1500	-	-
6	16500 fps	A-KL	19	5500	-	-
7	18400 fps	A-KL	23	5000	-	-
8	"	A-KL	23	5000	-	-
9	24000 fps	AE	22	2500	-	-
DOD FLIGHTS						
1		A	17	2220	-	-
2		A	3b	1570	-	-
3		A(2)	2,2	1380	-	-
4		A	4b	3480	-	-
5		A	8	2430	-	-
6		A	8	2430	-	-
7		A(2)	3a, 3a	3140	-	-
8		A(2)	3a, 3a	3140	-	-

MISSION CAPTURE
OPTION 1

LAUNCH SITE WTR YEAR 1986

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	VARIOUS HRW ALT	A(2)	14, 15	1400	—	—
DOD FLIGHTS						
1		A(3)	5, 5, 5	2205	—	—
2		A(2)	16, 16	5220	—	—

MISSION CAPTURE
OPTION 1

LAUNCH SITE ETR YEAR 1987

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	A	8	3500	–	–
2	"	A	8	3500	–	–
3	"	A	7	3000	–	–
4	"	A	7	3000	–	–
5	"	A(2)	6, 1	3100	–	–
6	"	A(3)	3, 3, 3	3300	–	–
7	"	A(2)	4, 3	2600	–	–
8	"	A(2)	4, 2	2300	–	–
9	"	A(2)	3, 3	2200	–	–
10	6900 / 55	A	10	6000	–	–
11	30 x 16 K / 29	A	11	800	–	–
12	16500 fps	A-KL	19	5500	–	–
13	"	A-KL	19	5500	–	–
14	24000 fps	A-E	22	2500	–	–
DOD FLIGHTS						
1		A	15	1970	–	–
2		A	6	3480	–	–
3		A	4a	3480	–	–
4		A	4a	3480	–	–
5		A	3b	1570	–	–
6		A(2)	2, 2	1380	–	–
7		A	8	2430	–	–
8		A	8	2430	–	–
9		A(2)	3a, 3a	3140		
10		A(2)	3a, 3a	3140		

MISSION CAPTURE

OPTION 1

LAUNCH SITE WTR YEAR 1987

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA - FLIGHTS						
1	VARIOUS CDW ALT.	A(2)	14, 15	1400	-	-
2	"	A(2)	12, 13	1850	-	-
DOD FLIGHTS						
1		A(3)	5,5,5	2205	-	-
2		B	12a	6000	12a	6000

MISSION CAPTURE
OPTION 1

LAUNCH SITE ETR YEAR 1988

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	A	B	3500	—	—
2	"	A	B	3500	—	—
3	"	A	7	3000	—	—
4	"	A	4	1500	—	—
5	"	A(3)	3,3,3	3300	—	—
6	"	A(3)	3,3,3	3300	—	—
7	"	A(3)	3,1,1	2100	—	—
8	1 AU.	A	9	750	—	—
DOD FLIGHTS						
1		A	17	2220	—	—
2		A	15	1970	—	—
3		A	36	1570	—	—
4		A(2)	2,2	1380	—	—
5		A	46	3480	—	—
6		A	46	3480	—	—
7		A	B	2430	—	—
8		A	8	2430	—	—
9		A(2)	3a,3a	3140	—	—
10		A(2)	3a,3a	3140	—	—

MISSION CAPTURE
OPTION 1

LAUNCH SITE WTR YEAR 1988

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	VARIOUS LOW ALT.	A(2)	14,15	1400	-	-
DOD FLIGHTS						
1		A(2)	16,16	5220	-	-

MISSION CAPTURE
OPTION 1

LAUNCH SITE ETR YEAR 1989

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	A	B	3500	–	–
2	"	A	B	3500	–	–
3	"	A	7	3000	–	–
4	"	A(2)	5, 1	2300	–	–
5	"	A(2)	5, 2	2600	–	–
6	"	A	5	1800	–	–
7	"	A(2)	3, 3	2200	–	–
8	30 x 16K/29	A	11	800	–	–
9	13000 fps	A	17	1000	–	–
10	"	A	17	1000	–	–
11	24000 fps	A-E	22	2500	–	–
12	22000 fps	A-E	24	3300	–	–
13	"	A-E	24	3300	–	–
DOD FLIGHTS						
1		A	17	2220	–	–
2		A	15	1970	–	–
3		A	6	3480	–	–
4		A(2)	2, 2	1380	–	–
5		A	10	2745	–	–
6		A	B	2430	–	–
7		A	8	2430	–	–

MISSION CAPTURE
OPTION 1

LAUNCH SITE WTR YEAR 1999

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	VARIOUS SEW ALT 500/99	A(3)	16,16,15	6200	—	—
2	"	A(2)	16,16	5200	—	—
3	"	A(2)	16,16	5200	—	—
4	VARIOUS LOW ALT	A(3)	12,13,14	2250	—	—
DOD FLIGHTS						
1		A(3)	5,5,5	2205	—	—
2		BA	12a	6000	12a	6000
3		A(2)	16,16	5220	—	—

MISSION CAPTURE
OPTION 1

LAUNCH SITE ETR YEAR 1990

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	A	8	3500	–	–
2	"	A	8	3500	–	–
3	"	A(2)	6, 1	3100	–	–
4	"	A(2)	6, 1	3100	–	–
5	"	A(3)	3, 3, 3	3300	–	–
6	1 AU	A(2)	9, 9	1500	–	–
7	6900 /55	A	10	6000	–	–
8	24000 fps	A-E	22	2500	–	–
DOD FLIGHTS						
1		A	17	2220	–	–
2		A	15	1970	–	–
3		A	4a	3480	–	–
4		A	4a	3480	–	–
5		A	3b	1570	–	–
6		A(2)	2, 2	1380	–	–
7		A	8	2430	–	–
8		A	8	2430	–	–
9		A(2)	3a, 3a	3140	–	–
10		A(2)	3a, 3a	3140	–	–

MISSION CAPTURE
OPTION 1

LAUNCH SITE WTR YEAR 1990

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	VARIOUS LOW ALT.	A(2)	14, 15	1400	-	-
DOD FLIGHTS						
1		A(3)	5, 5, 5	2205	-	-

2.3.2 Mission Model

The mission model for Option 1 is provided in the following table (Table 2-7). This is the mission model provided by the Government and is repeated here for completeness. The data shown on the table includes:

1. Mission Number (and DOD identification number for DOD missions)
2. Payload Weight (in pounds)
3. Payload Length and Diameter (in feet)
4. Number of mission per year (1980 through 1990) for both up payload and down payload traffic.
5. Total traffic for each payload
6. Subtotal yearly traffic for NASA and DOD
7. Total yearly traffic

TABLE 2-7

MISSION MODEL OPTION 1

		WEIGHT L / D	80	81	82	83	84	85	86	87	88	89	90	TOTALS
1		500 / 6 5	2	2	2	1	2	1	1	1	2	1	2	17
2		800 / 8 5	1	2		1		1		1		1		7
3		1100 / 10 6	3	7	3	3	1	5	5	6	7	2	3	45
4		1500 / 22 9	1	1		2	1	1		2	1			9
5		1800 / 17 10				3						3		6
6		2600 / 12 8	1		1			1		1			2	6
7		3000 / 20 10	1	1	2	2	1	2		2	1	1		13
8		3500 / 25 14	2	1	1	2	2	2	2	2	2	2	2	20
9		750 / 7 5	1		1		1		2		1		2	8
10		6000 / 12 8		1			1			1			1	4
11		800 / 8 5	1	1		1		1		1		1		6
12		1200 / 8 4				1		1		1		1		4
13		650 / 8 5				1		1		1		1		4
14		400 / 7 3				1	1	1	1	1	1	1	1	8
15		1000 / 6 5				1	1	1	1	1	1	1	1	8
16		2600 /				4		4				6		14
		/												

MISSION MODEL OPTION 1 (CONT.)

		WEIGHT L / D	80	81	82	83	84	85	86	87	88	89	90	TOTALS
17		1000 / 12 / 10	1									2		3
18		2000 / 12 / 10					2							2
19		5500 / 20 / 12							1	2				3
20		900 / 17 / 10			2		2							4
21		1600 / 15 / 10												0
22		2500 / 16 / 12							1	1		1	1	4
23		5000 / 17 / 12							2					2
24		3300 / 17 / 12					2					2		4
SUB-TOTAL	NASA		14 / 0	16 / 0	12 / 0	23 / 0	17 / 0	22 / 0	16 / 0	24 / 0	16 / 0	26 / 0	15 / 0	201 / 0

MISSION MODEL OPTION 1 (CONT.)

	DOD I.D.	WEIGHT L / D	80	81	82	83	84	85	86	87	88	89	90	TOTALS
25	2	690 / 12 / 5	2	2	2	2	2	2	2	2	2	2	2	22
26	3b	1570 / 15 / 5	1		1	1	1		1	1	1		1	8
27	15	1970 / 16 / 10	1		1	1	1	1		1	1	1	1	9
28	17	2200 / 12 / 10				2	2		1		1	1	1	8
29	12b	2400 / 20 / 10												0
30	6	3480 / 20 / 9						2		1		1		4
31	4a	3480 / 25 / 15		2			2			2			2	8
32	3a	1570 / 15 / 5	4		4	4	4		4	4	4		4	32
33	4b	3480 / 25 / 15	1		2	1		2	1		2	1		10
34	10	2745 / 20 / 9		1		1								2
35	8	2430 / 25 / 12.7	2	2	2	2	2	2	2	2	2	2	2	22
36	11a	850 / 9 / 6												0
37	11b	850 / 9 / 6												0
38	11c	850 / 9 / 6												0
39	5	735 / 3 / 5				3	3		3	3		3	3	18
40	16	2610 / 14.5 / 6.7				4		2	2		2	2		12
41	12a	6000 / 20 / 10				1 / 1		1 / 1		1 / 1		1 / 1		4 / 4
SUB-TOTAL	DOD		11 / 0	7 / 0	12 / 0	22 / 1	17 / 0	13 / 1	16 / 0	17 / 1	15 / 0	14 / 1	16 / 0	159 / 4
TOTAL			25 / 0	23 / 0	24 / 0	45 / 1	34 / 0	34 / 1	32 / 0	41 / 1	31 / 0	40 / 1	31 / 0	360 / 4

2.4 PROGRAMMATICS INPUT DATA

The following data was provided as a basic input to the programmatics studies. The first chart summarizes the total flights and hardware requirements. The second group of tables show the flight schedules and hardware requirements as a function of year. There are five tables in the group, an overall summary, NASA ETR, NASA WTR, DOD ETR and DOD WTR. These charts represent the data requested in NASA letter PD-TUG-P(028-74). The next chart shows the same flight requirements data in the format used by MDAC in the study. The final chart shows the usage of indivisual Tugs to accomplish the mission model.

At the top of the chart, the number of flights per year is shown and the number of Tug expendable flights. The number of Tugs required were established by first determining the number of Tugs necessary to accomplish the 1990 requirements and working backward from that point. The maximum number of flights any Tug can perform in a year is established first by summing the Tug ground turn-around time and the mission time which results in the minimum mission turn-around time. In option 1 the ground turn-around time is 26.7 days and the average mission time is 1.7 days. The mission turn-around time is thus 28.4. The maximum number of cycles (flights) in a year is then 12.

Using this number and assuming that the maximum number of flights that an expended Tug can make in the year that it is expended is 6 (one-half the maximum turn-around in a year), the fleet of 3 for 1990 is established. Working backward from there it can be seen that in 1989 the three expendable requirements and the necessary in 1990 make up the inventory requirement. The resulting data show that to carry-out the operations a total of 10 Tugs are required during the program.

The major influence on fleet sizing is the number of expendable Tug missions required. If, for example, no expendable missions were required the required fleet size could be reduced to three vehicles.

CONFIGURATION OPTION 1

	REQUIRED	ACCOMPLISHED
DEPLOYMENTS	360	341
RETRIEVALS	4	4
FLIGHT REQUIREMENTS (NASA/DOD)		
# ETR LAUNCHES		104 / 89
# WTR LAUNCH		16 / 16
# REFLIGHTS DUE TO LOSSES		3
FLIGHT COMPOSITION		
EXPENDABLES (E)		8
TUG WITH BURNER II (KS_1)		—
TUG WITH POLARIS (KS_2)		9
TUG (BASIC)		208
VEHICLE LOSSES/REFLIGHTS		3
		(228)
FLEET SIZE REQUIREMENTS		
FOR OPERATIONS		10
FOR RELIABILITY		3
TOTAL		13
REQUIREMENT AT IOC (MIN)		1
FLIGHTS PER ARTICLE		22.5

TURNAROUND CYCLE 28.4 DAYS LAUNCH TO LAUNCH (CALENDAR DAYS)

F L I G H T S C H E D U L E

TUG CONCEPT OPTION 1

LAUNCH SITE ETR/WTR AGENCY NASA/DOD

COMPANY MDAC

	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
TUG (BASIC)**		3	14	16	30	(2) 26	22	(1) 21	(1) 28	20	(3) 28	(1) 20	(8) 228
AUXILIARY STAGE				(2)		(2)		(3)	(2)				(9)
DROP TANKS													0
(OTHER)	1*												1
SHUTTLE **	1*	3	14	16	30	26	22	21	28	20	28	20	229

() DENOTES NUMBER EXPENDED.

REMARKS: 20 payloads not accommodated due to Shuttle limit of 3 Tug flights in 1980

* IVU Test Flight

** Includes reflights due to Tug reliability losses

F L I G H T S C H E D U L E

TUG CONCEPT OPTION 1

LAUNCH SITE ETR AGENCY NASA

COMPANY MDAC

	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
TUG (BASIC)		3	8	8	11	(2) 13	9	(1) 9	(1) 14	8	(3) 13	(1) 8	(8) 104
AUXILIARY STAGE				(2)		(2)		(3)	(2)				(9)
DROP TANKS													0
(OTHER)	1*												1
SHUTTLE	1*	3	8	8	11	13	9	9	14	8	13	8	105

( ) DENOTES NUMBER EXPENDED.

REMARKS: 9 NASA payloads not accommodated due to Shuttle limit of 3 Tug flights in 1980

* IVU Test Flight

F L I G H T S C H E D U L E

TUG CONCEPT OPTION 1

LAUNCH SITE ETR AGENCY DOD

COMPANY MDAC

	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
TUG (BASIC)			6	8	11	11	8	8	10	10	7	10	89
AUXILIARY STAGE													0
DROP TANKS													0
(OTHER)													0
SHUTTLE			6	8	11	11	8	8	10	10	7	10	89

() DENOTES NUMBER EXPENDED.

REMARKS: 11 DOD payloads not accommodated due to Shuttle limit of 3 Tug flights in 1980

F L I G H T S C H E D U L E

TUG CONCEPT OPTION 1

LAUNCH SITE WTR AGENCY NASA

COMPANY MDAC

	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
TUG (BASIC)					3	1	3	1	2	1	4	1	16
AUXILIARY STAGE													
DROP TANKS													
(OTHER)													
SHUTTLE					3	1	3	1	2	1	4	1	16

() DENOTES NUMBER EXPENDED.

REMARKS:

F L I G H T S C H E D U L E

TUG CONCEPT OPTION 1

LAUNCH SITE WTR AGENCY DOD

COMPANY MDAC

	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
TUG (BASIC)					4	1	2	2	2	1	3	1	16
AUXILIARY STAGE													
DROP TANKS													
(OTHER)													
SHUTTLE					4	1	2	2	2	1	3	1	16

() DENOTES NUMBER EXPENDED.

REMARKS:

FLIGHT REQUIREMENTS

OPTION 1

	80	81	82	83	84	85	86	87	88	89	90	TOTAL
ETR												
NASA	3	8	6	11	9	9	5	11	8	10	7	87
DOD	-	6	8	11	11	8	8	10	10	7	10	89
NASA EXPENDABLE	-	-	-	-	2	-	1	1	-	3	1	8
NASA KICK STAGE	-	-	2	-	2	-	3	2	-	-	-	9
DOD KICK STAGE	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	3	14	16	22	24	17	17	24	18	20	18	193
WTR												
NASA	-	-	-	3	1	3	1	2	1	4	1	16
DOD	-	-	-	4	1	2	2	2	1	3	1	16
TOTAL	0	0	0	7	2	5	3	4	2	7	2	32
REFLIGHTS / LOSSES				1			1			1		3

EQUAL USAGE SCHEDULE

OPTION 1

	80	81	82	83	84	85	86	87	88	89	90	TOTAL
NUMBER OF FLIGHTS	3	14	16	29	26	22	20	28	20	27	20	225
NUMBER OF EXPENDED TUGS					2		1	1		3	1	8
TUG ID 1	2	4	2	3	3							14
2	1	6	2	6	6							21
3		4	4	6	5	3	2					24
4			4	6	4	3	3	3				23
5			2	4	4	4	4	2	2	2		24
6			2	4	4	4	4	2	2	2		24
7						8	7	4	3	2		24
8								10	10	2	2	24
9								7	3	8	6	24
10										11	12	23
REFLIGHTS / LOSSES				1			1			1		3

2.5 SENSITIVITY STUDY DATA

2.5.1 Two Year IOC Delay

A two year IOC delay in the Option 1 program results in the loss of all missions in 1980 and 1981. In 1982 normal program results build up will allow the availability of three vehicles in 1982 thus allowing all 1982 missions to be accommodated.

The total number of flights necessary to accommodate the 9 year mission model (Option 1 mission model less the first two years) is 208. A total of 48 payloads in 1980 and 1981 are not accommodated due to the delay in IOC.

2.5.2 >36 Hour Duration

Impact of increasing the duration capability of the Option 1 Tug on the program is disguised by the capture analysis ground rules which allow multi-payload deployment with no longitudinal positioning between payloads. If the Option 3 ground rules were used, the 36 hour capability would limit synchronous operations to single deployment. If this were true the extension of duration capability to 3 days would allow multi-payload capability with longitudinal positioning and would save about 58 flights. Extension to 6 days would have only a small impact upon the mission capture (about one flight per year). These savings are due to the increased time available to walk the longitudinal position between the payloads.

MCDONNELL DOUGLAS

SPACE TUG SYSTEMS STUDY (CRYOGENIC)
SEPTEMBER DATA DUMP

VOLUME 4 Mission Accomplishment
Book 2 Option 2

SEPTEMBER 1973

PREPARED BY: SPACE TUG STUDY TEAM

APPROVED BY: L. Q. Westmoreland

L. Q. WESTMORELAND
STUDY MANAGER

PREPARED FOR NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MARSHALL SPACE FLIGHT CENTER
UNDER CONTRACT NO. NAS8-29677

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY-WEST

5301 Bolsa Avenue, Huntington Beach, CA 92647

PREFACE

This study report for the Tug Program is submitted by the McDonnell Douglas Astronautics Company (MDAC) to the Government in partial response to Contract Number NAS8-29677.

The current results of this study contract are reported in eight volumes:

Volume 1 – Summary, Program Option 1
Volume 2 – Summary, Program Option 2
Volume 3 – Summary, Program Option 3

These three summary volumes present the highlights of the comprehensive data base generated by MDAC for evaluating each of the three program options. Each volume summarizes the applicable option configuration definition, Tug performance and capabilities, orbital and ground operations, programmatic and cost considerations, and sensitivity studies. The material contained in these three volumes is further summarized in the Data Dump Overview Briefing Manual.

Volume 4 – Mission Accomplishment. (3 Books and 1 Supplement Bound Together)

This volume contains mission accomplishment analysis for each of the three program options and includes the tug system performance, mission capture, and fleet size analysis.

Volume 5 – Systems (3 Books)

This volume presents the indepth design, analysis, trade study, and sensitivity technical data for each of the configuration options and each of the Tug systems i.e., structures, thermal, avionics, and propulsion. Interface with the Shuttle and Tug payloads for each of the three options is defined.

Volume 6 – Operations (3 Books)

This volume presents the results of orbital and ground operations trades and optimization studies for each option in the form of operations descriptions, time lines, support requirements (GSE, manpower, networks, etc.), and resultant costs.

Volume 7 – Safety (3 Books)

This volume contains safety information and data for the Tug Program. Specific safety design criteria applicable to each option are determined and potential safety hazards common to all options are identified.

Volume 8 – Programmatics and Cost (3 Books)

This volume contains summary material on Tug Program manufacture, facilities, vehicle test, schedules, cost, project management SR&T, and risk assessment for each option studied.

These volumes contain the data required for the three options which were selected by the Government for this part of the study and are defined as:

A. Option 1 is a direct development program (I.O.C.: Dec 1979). It emphasizes low DDT&E cost; the deployment requirement is 3500 pounds into geosynchronous orbit, it does not have retrieval capability, and it is designed for a 36-hour mission. MDAC has also prepared data for an alternative to Option 1 which deviates from certain requirements to achieve the lowest practicable DDT&E cost.

B. Option 2 is also a direct development program (I.O.C.: 1983). It emphasizes total program cost effectiveness in addition to low DDT&E cost. The deployment requirement is 3500 pounds minimum into geosynchronous orbit and 3500 pounds minimum retrieval from geosynchronous orbit.

C. Option 3 is a phased development program (I.O.C.: 1979 phased to I.O.C. 1983). It emphasizes minimum initial DDT&E cost and low total program cost. The initial Tug capability will deploy a minimum of

3500 pounds into geosynchronous orbit without retrieval capability, however, through phased development, it will acquire the added capability to retrieve 2200 pounds from geosynchronous orbit. The impact of increasing the retrieval capability to 3500 pounds is also provided.

CONTENTS

Section 1

PERFORMANCE

1.1 PERFORMANCE GROUND RULES

The payload performance was determined using the classical impulsive velocity equation. The velocities employed were based on the three dimensional finite burning trajectory analyses performed during Task 1. Since most of the missions in the mission model did not exceed three days duration, this figure was used for establishing performance capability even though subsystems are sized for six days. A detailed simulation of the basic geosynchronous deployment mission taking into account the actual losses associated with each engine start and the velocity contributed by propellant settling forces was used to determine an equivalent specific impulse penalty of four seconds which was then used for all missions.

For the geosynchronous transfer, a velocity of 13,972 fps was used which represents the most unfavorable situation (from a performance point of view) of no low orbit phasing being required and the resulting injection to the transfer orbit being performed with only one burn instead of two. This velocity is approximately 80 fps greater than the most favorable two burn transfer injection. For the return, a velocity of 13,920 fps was used.

The following weights and engine data were also employed in the performance computations:

Shuttle Capability	65,000
Ancillary equipment (to install Tug in the Orbiter bay)	2,066
Vented during ascent	269
Tug gross weight at deployment from Orbiter bay	62,665
Tug burnout weight (includes FPR)	6,430
Propellant capacity (@5.5 EMR)	55,500
Engine chilldown and propellant settling (each start)	20
Vented in flight	78
Attitude control propellant	95
Fuel Cell Reactants	83
Engine	Category II RL10
Thrust	15,000
I_{sp} (@6.0:1 EMR)	459.2

1.2 GEOSYNCHRONOUS PERFORMANCE

Based on the foregoing ground rules and data, the following geosynchronous orbit performance capabilities were determined at the nominal 6.0:1 EMR:

Deployment	7,640 (7,892)
Retrieval	4,814
Round Trip	2,953 (3,067)

By off-loading lox only on the round trip and deployment missions, an EMR of 5.5 could be used yielding a three second increase in ISP and the pyaloads shown in parentheses. For mission of greater (or less) than three days, the increase (or decrease) in on-orbit consumables must be corrected for using the factors given in Section 1.4.2. Figure 1.2-1 shows how the payload delivery capability decreases as payload is returned.

1.3 PERFORMANCE ENVELOPE

Figures 1.3-1, -2, and -3 present the payload-velocity envelope for the Option 2 Tug starting from 28.5 deg, 55 deg, and 90 deg inclinations, respectively. The significant variation with inclination reflects the Shuttle performance with launch azimuth. For missions below geosynchronous, specific impulse could be increased by off loading LOX only initially to reduce the EMR to 5.5 and gain up to three seconds.

1.4 PERFORMANCE SENSITIVITIES

1.4.1 General Mission Trade Factors

The sensitivity of payload to the two principal performance factors, —Tug inert weight and I_{sp}— are presented as a function of mission velocity in Figure 1.4-1.

1.4.2 Geosynchronous Trade Factors

Specific trade factors for the geosynchronous missions are given in Table 1.4-1. The inert weight factor is applicable to any weight carried throughout the mission, such as structure and residual propellants. The gross weight factor can correct for variations in the Tug gross weight at first ignition such as Shuttle capability, ancillary equipment or propellants vented during ascent.

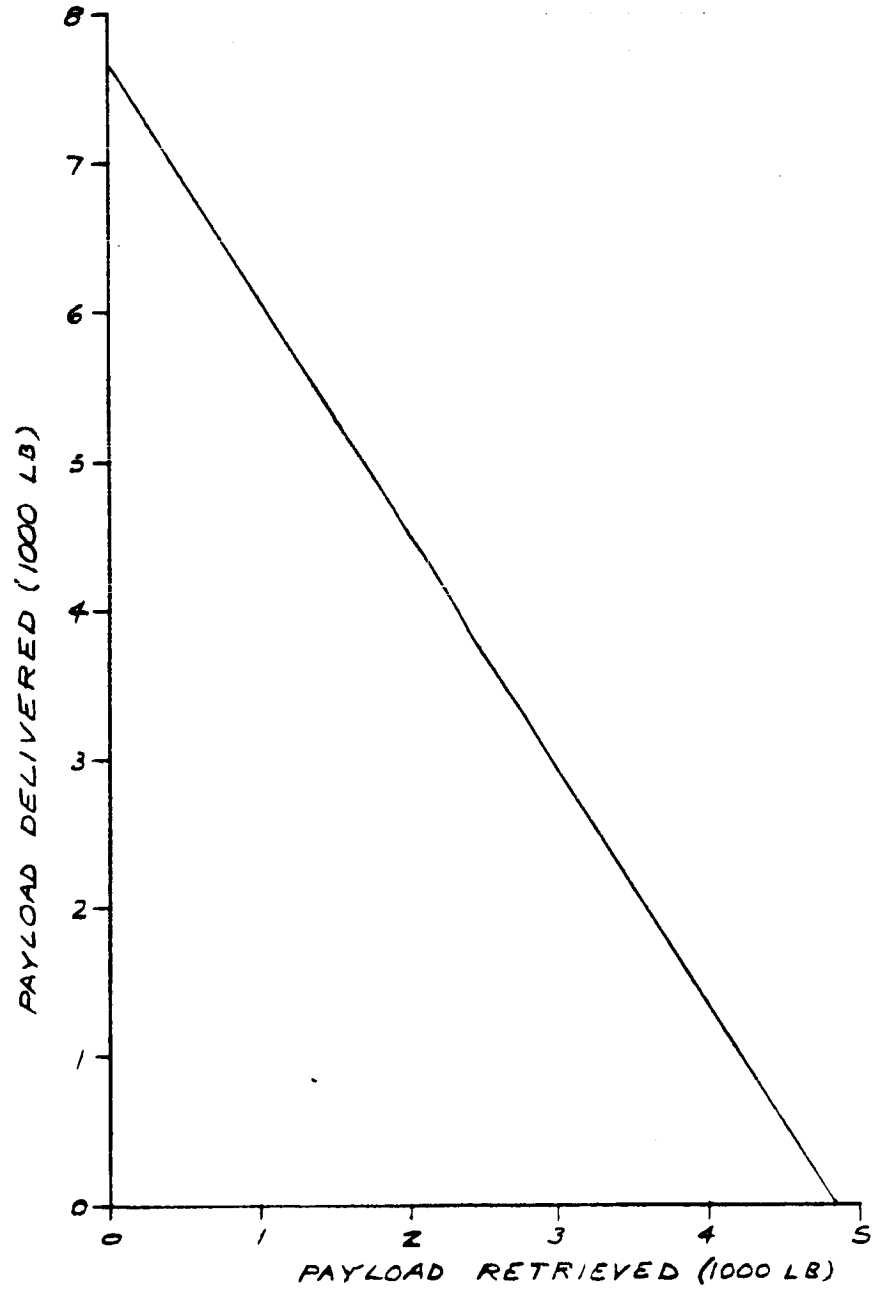
1.5 MISSION PERFORMANCE

The performance capability for each mission in the mission model was computed for each basic mission mode. The missions are defined in Table 1.5-1. Table 1.5-2 is a computer printout of the results and includes the velocities

DOUGLAS

GEOSYNCHRONOUS PERFORMANCE

CONFIGURATION OPT 2



PREPARED BY: S.P.T. MODEL REVISED

REPORT NO. DATE

PAGE NO.

REFERENCE

FORM 28-BP-4G (REV. 6-71)

ALBANENE® LA4834

PERFORMANCE CAPABILITY

CONFIGURATION OPT 2

W_{BO} 6430

I_{SP} 459.2

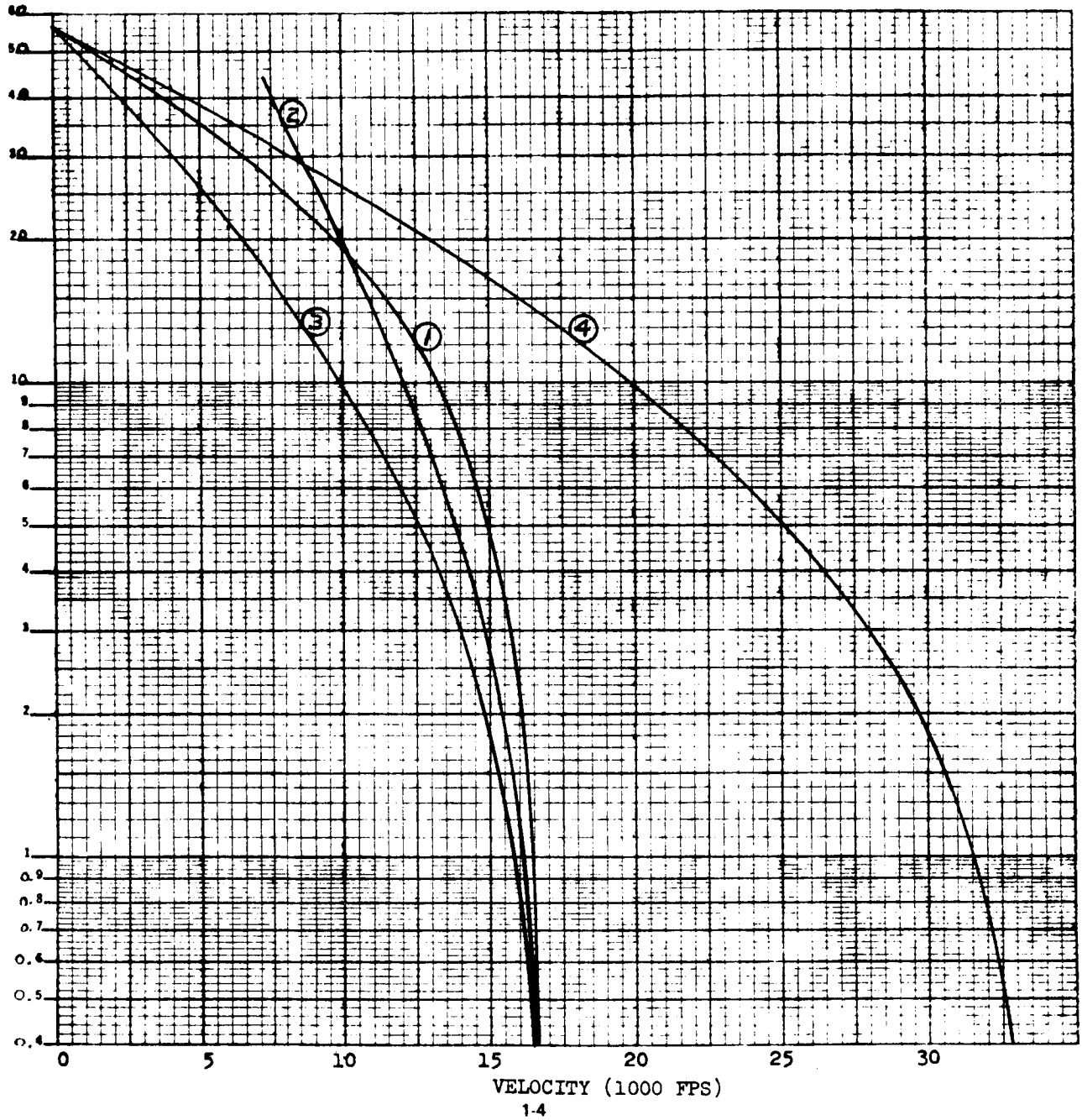
INCL 28.5°

① DEPLOY

② RETRIEVE

③ ROUND TRIP

④ EXPENDABLE



PERFORMANCE CAPABILITY

CONFIGURATION OPT 2

W_{BO} 6430

I_{SP} 459.2

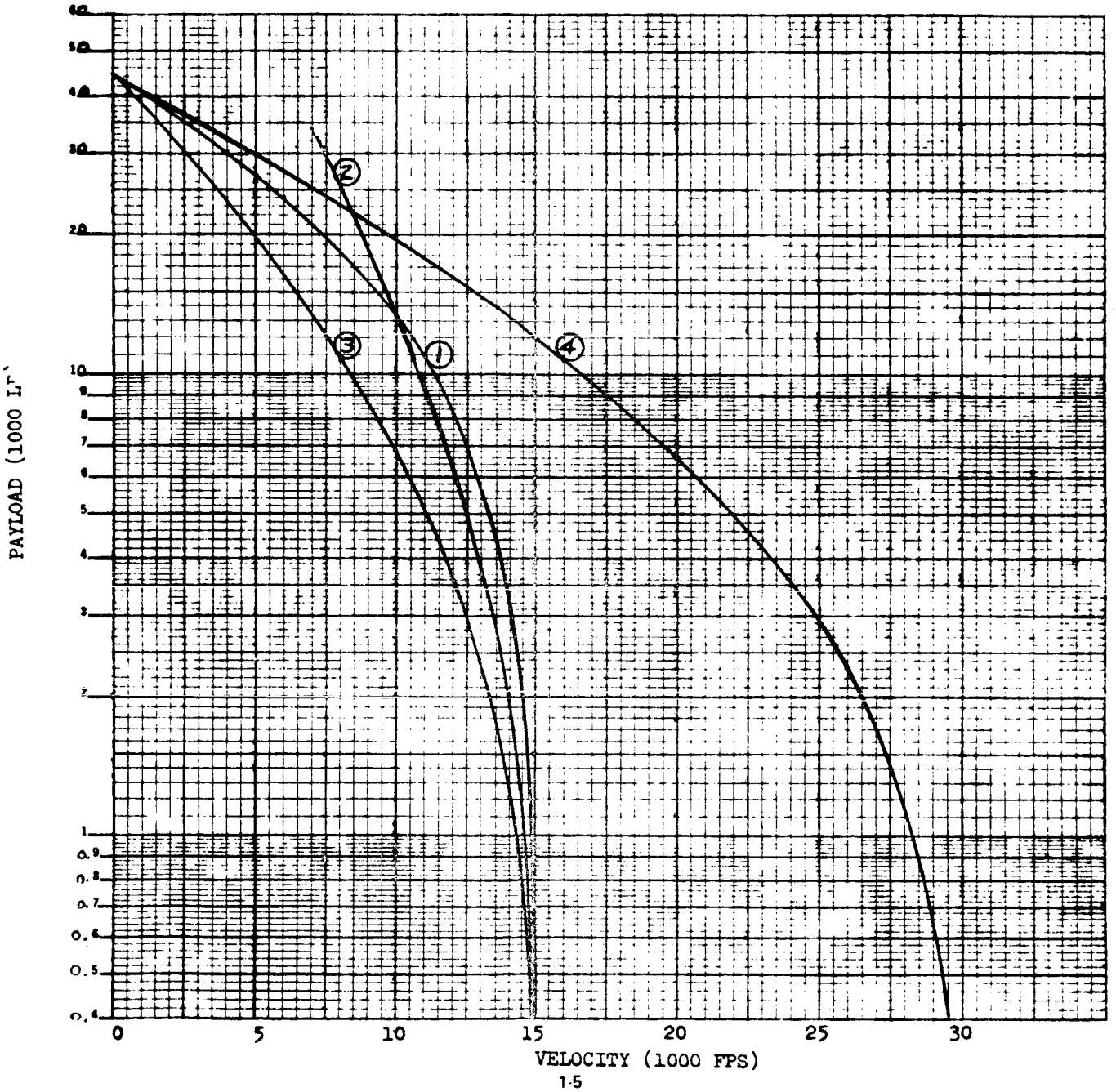
INCL 55°

① DEPLOY

② RETRIEVE

③ ROUND TRIP

④ EXPENDABLE



PERFORMANCE CAPABILITY

CONFIGURATION OPT 2

W_{BO} 6430

I_{SP} 459.2

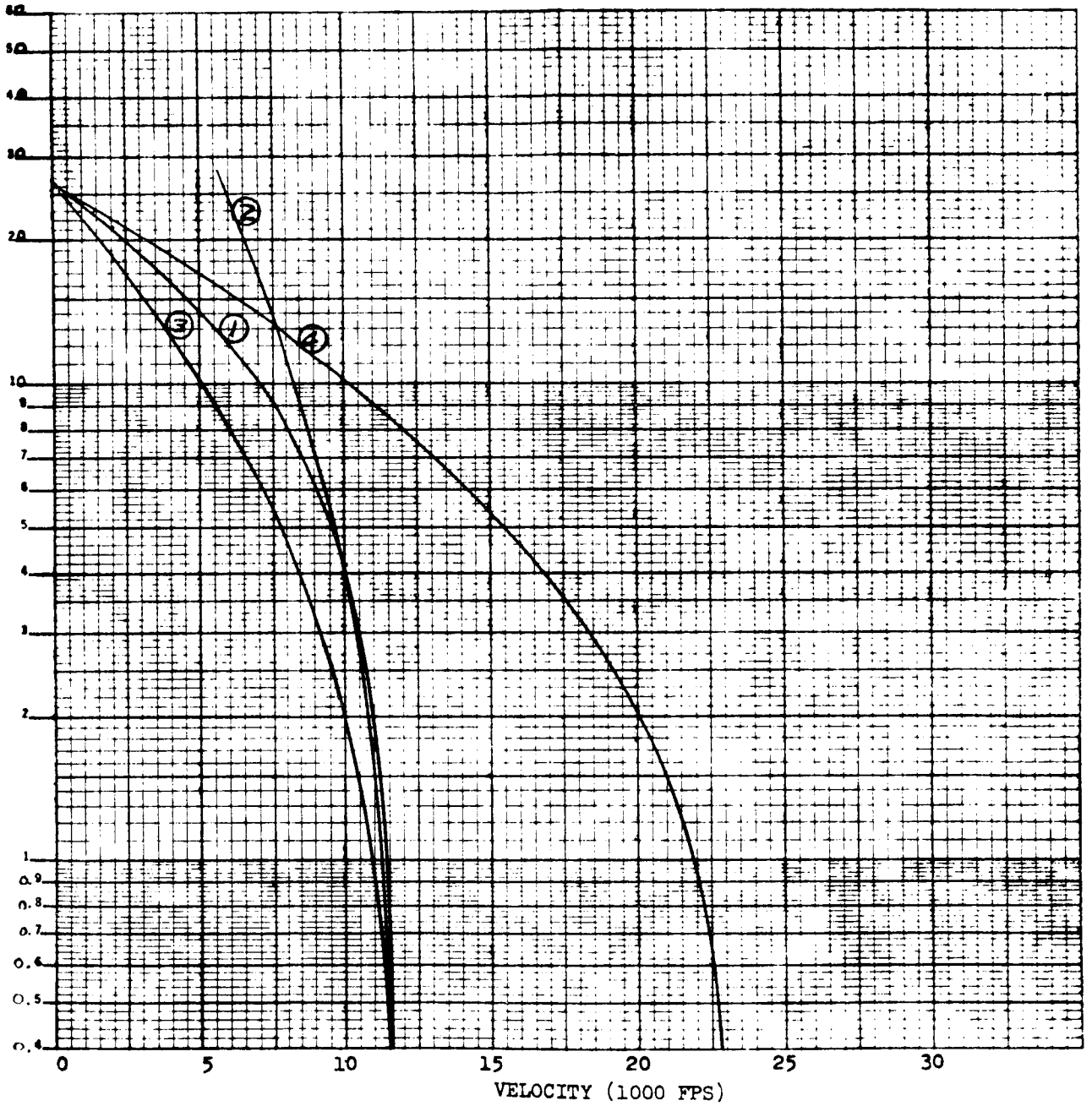
INCL 90°

① DEPLOY

② RETRIEVE

③ ROUND TRIP

④ EXPENDABLE

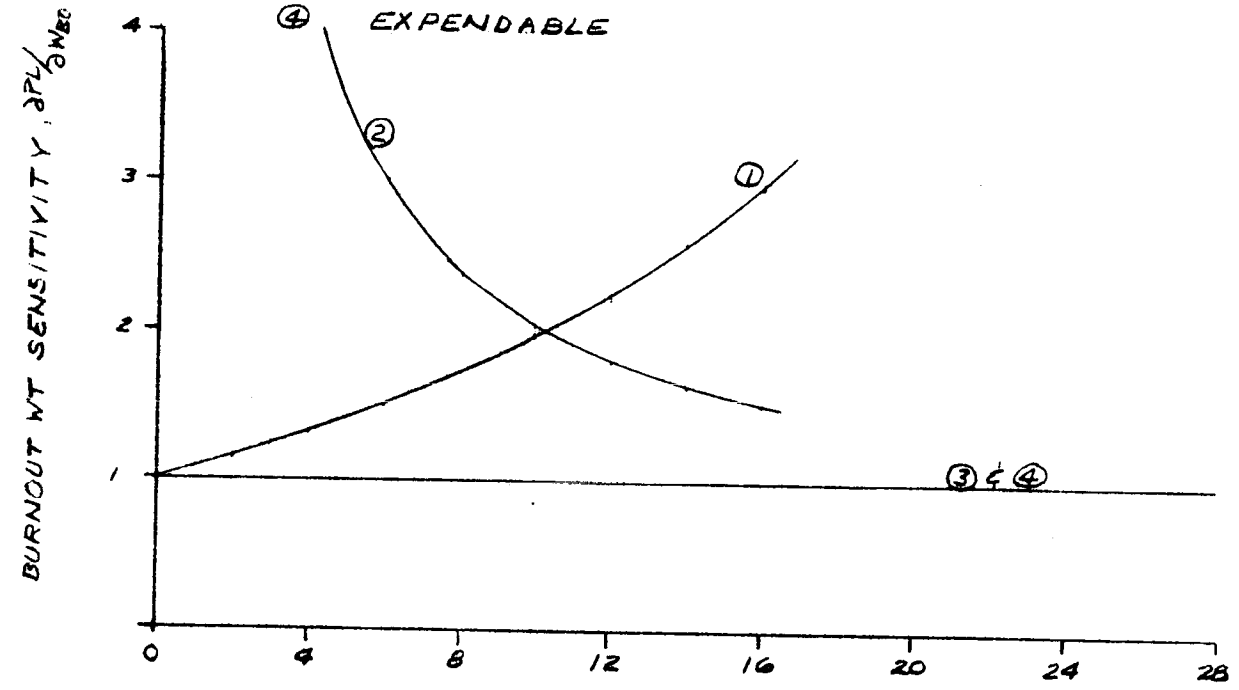


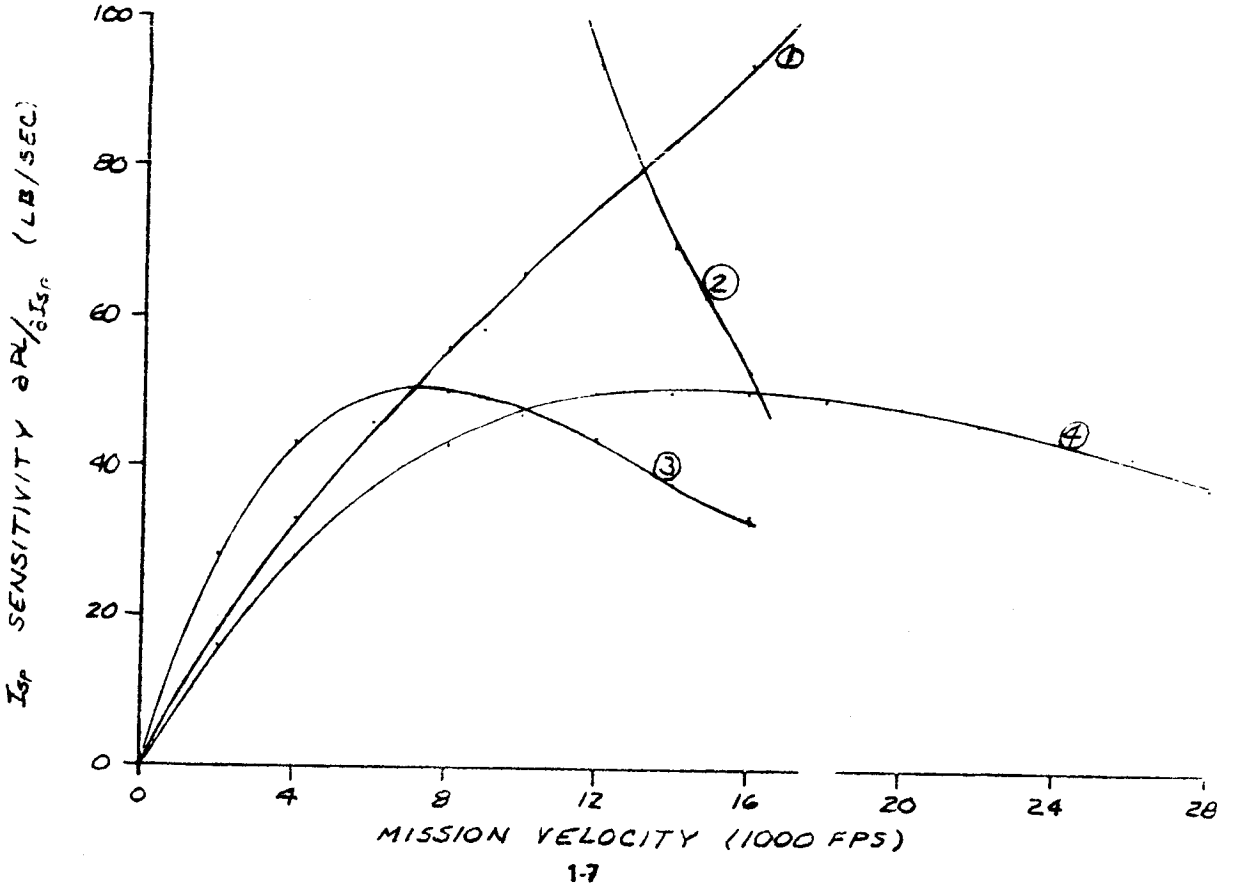
DOUGLAS

PERFORMANCE SENSITIVITY

CONFIGURATION OPTION 2

① DEPLOY
② RETRIEVE
③ ROUND TRIP
④ EXPENDABLE





REPORT NO. _____ REVISED _____
PAGE NO. _____ DATE: _____
MODEL _____
PREPARED BY: _____
REFERENCE _____

FORM 28-BP-46 (REV. 6-71)

K+E ALBANENE® LA 4834 TRACING PAPER

Table 1.4-1

GEOSYNCHRONOUS MISSION TRADE FACTORS

	DEPLOY	RETRIEVE	ROUND TRIP
Burnout Weight: $\partial PL / \partial W_{EO}$	-2.57	-1.64	-1
Specific Impulse: $\partial PL / \partial I_{sp}$	84	70	38
Gross Weight: $\partial PL / \partial W_o$	.39	.25	.15
Orbit Losses: $\partial PL / \partial W_{OL}$	-1	-.64	-.39

Table 1.5-1

MISSION DESCRIPTIONS

Mission No.	H_a x H_p (nmi)	Incl.	Remarks
1-8	19323	0	Synchronous orbit - single burn transfer orbit injection
1-8A	19323	0	Synchronous orbit - two burn transfer injection
1-8B	19323	0	Synchronous orbit - two burn transfer injection with 600 fps for multiple payload deployments
9	1AU	Eclip.	
10	6900	55°	
10A	6900	55°	Alternate - Shuttle launched into 28.5°
11	16Kx30K	20°	
12	180x1800	90°	
13	1Kx20K	90°	
13A	1Kx20K	90°	ETR Alternate - Shuttle launched into 28.5°
13B	1Kx20K	90°	ETR Alternate - Shuttle launched into 55°
14	300x3000	90°	
15	700	100°	
16	500	99.2°	
17-8	Interplanetary		ΔV - 13000
19			16500
20			23000
21-2			24000
23			18400
24			22000
D11	58K	0,30,60	
D10	860x21K	63.4	Shuttle launch into 63.4° WTR
D10A	860x21K	63.4	ETR Alternate - Shuttle launched into 55°
D5	750	99°	
D3	13.6Kx25K	60°	Shuttle launched into 60° WTR
D3A	13.6x25K	60°	ETR Alternate - Shuttle launched into 55°
D12	300	104°	
D16	400	98.3°	

CØNFIGURATIØN ØPT 2 STAGE WT=6430.00 ISP=459.20 DELISP=4.00

MISSIØN	GRØSS-WT V-ØUT	PL-RØUND V-BACK	PL-DEPLØY	PL-RETRIEVE	PL-EXPEND
1-8	62665.00 13972.00	2900.97 13920.00	7504.50	4729.05	17708.20
1-8A	62665.00 13890.00	2953.36 13920.00	7640.02	4814.46	17843.73
1-8B	62665.00 14190.00	2576.71 14220.00	6803.62	4147.47	17351.56
9	62665.00 14160.00	2515.42 14350.00	6701.01	4027.12	17400.33
10	50665.00 9700.00	7041.89 9700.00	13656.17	14539.03	19695.72
10A	62665.00 12760.00	4541.49 12760.00	10853.71	7808.99	19790.77
11	62665.00 12450.00	5015.93 12450.00	11736.50	8759.61	20351.70
12	32665.00 2285.00	17479.28 2285.00	20430.62	121000.06	21516.32
13	32665.00 8400.00	3942.95 8400.00	6996.99	9033.53	11977.40
13A	62665.00 13460.00	3541.27 13460.00	8877.61	5891.30	18566.99
13B	50665.00 11200.00	4546.61 11200.00	9768.05	8505.62	17152.41
14	32665.00 3600.00	13549.12 3600.00	17324.65	62172.59	19116.39
15	26665.00 1700.00	14710.73 1700.00	16521.33	134232.19	17312.73
16	26665.00 1120.00	16453.28 1120.00	17760.87	223484.31	18271.88
17-8	62665.00 13140.00	3908.72 13250.00	9659.28	6565.52	19119.18
19	62665.00 16740.00	.00 17210.00	.00	.00	13551.32

20	62665.00 23550.00	.00 24500.00	.00	.00	6121.14
21-2	62665.00 24600.00	.00 25500.00	.00	.00	5252.79
23	62665.00 18720.00	.00 19550.00	.00	.00	11024.61
24	62665.00 22500.00	.00 23500.00	.00	.00	7054.02
D11	62665.00 13930.00	2921.38 13930.00	7562.46	4760.28	17777.53
D10	48665.00 8500.00	8814.24 8500.00	15748.55	20018.09	20807.13
D10A	50665.00 9800.00	6859.16 9800.00	13392.96	14059.91	19517.94
D5	26665.00 1770.00	14509.61 1770.00	16373.53	127459.19	17199.53
D3	48665.00 11850.00	3217.77 11850.00	7226.88	5800.43	15238.16
D3A	50665.00 11920.00	3518.71 11920.00	7940.63	6318.73	16021.10
D12	26665.00 500.00	18475.09 500.00	19116.72	550454.06	19340.03
D16	26665.00 850.00	17312.75 850.00	18347.27	307044.75	18731.49

derived from Task I. The gross weight reflects the Shuttle delivery capability to the appropriate parking orbit inclinations. In several cases, alternate mission profiles are shown starting from different inclinations. The capabilities with a kick stage were also determined for use in the mission capture analysis but are not shown simply to avoid classifying any data.

Section 2

CAPTURE ANALYSIS - OPTION 2

2.1 FLIGHT SUMMARY

The data provided in Section 2.1.1 represents a summary of the mission captured by the Option 2 program based upon all constraints of the system potential (Tug capability) and the program schedule (Tug and related support systems availability). Section 2.1.2 identified the missions, from the Option Mission Model, which are not captured by the program and also includes the rationale for their exclusion.

2.1.1 Flight Summary Data

Tables 2-1 through 2-5 present the number of flights per year for each of the flight modes used in Option 2. Also shown are the total Shuttle and Tug flights and the number of missions identified as requirements in the Option Mission Model. On Table 2-1 the number of missions accomplished is identified.

The mission modes used in this option are defined as follows:

Deploy

Single Payload - The deployment of one payload to one location and velocity vector and return of the Tug to the Shuttle.

Multi - 2 Payload - The deployment of two payloads to one location and velocity vector and return of the Tug to the Shuttle.

Multi - 3 Payloads - The deployment of three payloads to one location and velocity vector and return to the Shuttle.

Kick Stage - Large - The deployment of one or more payloads to one location and velocity vector using a Polaris kick stage as a second stage to the Tug. The kick stage is expended and the Tug returns to the Shuttle.

Expendable - The deployment of one payload to one location and velocity vector. The Tug is expended.

Retrieval

Single Payload - The retrieval of one payload from one location and return to the Shuttle.

Round Trip

Deploy 1/Retrieve 1 - Deploy one payload at one location and velocity vector (maneuver 60° phase angle position for synchronous equatorial mission between deployment and retrieval), retrieve one payload and return to the Shuttle.

Deploy Multi/Retrieve 1 - Deploy one payload at one location and velocity vector, maneuver to a second position and velocity vector and deploy second payload, if three satellites are to be deployed, maneuver to a third position and velocity vector and deploy third satellite and retrieve another satellite at that position (for synchronous equatorial mission each maneuver shall be 60° phase angle).

Sortie - Carry a payload to one orbital location, remain in that orbit for 130 hours and return the payload to the Shuttle.

FLIGHT SUMMARY—OPTION TOTAL—OPTION 2

Flight Mode		Calendar Year											Total
		80	81	82	83	84	85	86	87	88	89	90	
Totals	Shuttle					20	32	35	37	30	33	35	222
	Tug					20	32	35	37	30	33	35	222
Tug Flight Distribution	Deploy												
	Single Payload					6	2	1	5	2	4	3	23
	Multi--2 Payloads					1	1	1	4		4	1	12
	Multi--3 Payloads					1	1	1	2	3	2	2	12
	Kick-Stage — Large							3	2				5
	Expendable							1	1		3	1	6
	Retrieve												
	Single Payload						1	6	6	4	1	6	24
	Round Trip												
	Deploy 1/Retrieve 1					8	24	22	15	19	16	21	125
	Deploy Multi/Retrieve 1					4	2		1	2	2	1	12
	Sortie						1		1		1		3
Mission Model	Total												
	Deploy					37	37	32	41	34	43	34	258
	Retrieve					27	28	28	23	25	20	28	179
	Total					64	65	60	64	59	63	62	437
Accomplishment	Total					39	65	60	64	59	63	62	412

FLIGHT SUMMARY—NASA—OPTION 2

Flight Mode		Calendar Year											Total
		80	81	82	83	84	85	86	87	88	89	90	
Totals	Shuttle					10	20	18	17	13	19	17	114
	Tug					10	20	18	17	13	19	17	114
Tug Flight Distribution	Deploy												
	Single Payload					4			3	1	3	1	12
	Multi--2 Payloads							1			4	1	6
	Multi--3 Payloads								1	2			3
	Kick-Stage Mode							3					3
	Expendable							1			3	1	5
	Retrieve												
	Single Payload						1	3	2	3		3	12
	Round Trip												
	Deploy 1/Retrieve 1					5	17	10	10	5	7	11	65
	Deploy Multi/Retrieve 1					1	2			2	2		7
	Sortie								1				1
Mission Model	Total												
	Deploy					17	22	16	17	16	26	15	129
	Retrieve					14	20	13	13	10	9	14	93

FLIGHT SUMMARY—DOD—OPTION 2

Flight Mode		Calendar Year											Total
		80	81	82	83	84	85	86	87	88	89	90	
Totals	Shuttle					10	12	17	20	17	14	18	108
	Tug					10	12	17	20	17	14	18	108
Tug Flight Distribution	Deploy												
	Single Payload					2	2	1	2	1	1	2	11
	Multi--2 Payloads					1	1		4				6
	Multi--3 Payloads					1	1	1	1	1	2	2	9
	Kick-Stage Mode								2				2
	Expendable								1				1
	Retrieve												
	Single Payload							3	4	1	1	3	12
	Round Trip												
	Deploy 1/Retrieve 1					3	7	12	5	14	9	11	61
	Deploy Multi/Retrieve 1					3			1				4
	Sortie						1				1		2
Mission Model	Total												
	Deploy					20	15	16	24	18	17	19	129
	Retrieve					13	8	15	10	15	11	14	86

FLIGHT SUMMARY—ETR—OPTION 2

Flight Mode		Calendar Year											Total
		80	81	82	83	84	85	86	87	88	89	90	
Totals	Shuttle					20	24	26	29	24	24	30	177
	Tug					20	24	26	29	24	24	30	177
Tug Flight Distribution	Deploy												
	Single Payload					6	2	1	5	2	4	3	23
	Multi--2 Payloads					1		1	4		1	1	8
	Multi--3 Payloads					1	1		1	3	1	1	8
	Kick-Stage Mode							3	2				5
	Expendable							1	1		3	1	6
	Retrieve												
	Single Payload						1	2	2	2	1	4	12
	Round Trip												
	Deploy 1/Retrieve 1					8	19	18	14	15	13	20	107
	Deploy Multi/Retrieve 1					4	1			2	1		8
	Sortie												
Mission Model	Total												
	Deploy					32	26	25	33	30	27	29	202
	Retrieve					23	21	20	16	19	15	24	138

FLIGHT SUMMARY—WTR—OPTION 2

Flight Mode		Calendar Year											Total
		80	81	82	83	84	85	86	87	88	89	90	
Totals	Shuttle						8	9	8	6	9	5	45
	Tug						8	9	8	6	9	5	45
Tug Flight Distribution	Deploy												
	Single Payload												
	Multi--2 Payloads						1				3		4
	Multi--3 Payloads							1	1		1	1	4
	Kick-Stage Mode												
	Expendable												
	Retrieve												
	Single Payload							4	4	2		2	12
	Round Trip												
	Deploy 1/Retrieve 1						5	4	1	4	3	2	19
	Deploy Multi/Retrieve 1						1		1		1		3
	Sortie						1		1		1		3
Mission Model	Total												
	Deploy					5	11	7	8	4	16	5	56
	Retrieve					4	7	8	7	6	5	4	41

2.1.2 Missions Not Captured

A normal build-up of vehicles results in a limitation in the number of flights possible in the first year of operation. In the case of Option 2 a total of 20 are flown in the first year. The selection of payloads was based upon the following rationale.

1. WTR flights were not flown which would allow WTR start-up costs to fall later in the program.
2. All expendable missions would not be flown which would reduce initial fleet size.
3. Missions requiring kick stages would not be flown. This would allow Tug/kick stage integration and kick stage production to be delayed two years since no kick stages are required in 1985 either.
4. Retrieval missions are of lesser priority than deployment missions.

Using this rationale, 27 deployments out of 37 required and 12 retrievals out of 27 were accomplished. The missions not accomplished in 1984 are listed below.

NASA		DOD	
MISSION	NO. OF PAYLOADS	MISSION	NO. OF PAYLOADS
ETR DEPLOYMENTS		ETR DEPLOYMENTS	
20	2	8	1
24	2		
ETR RETRIEVALS		ETR RETRIEVALS	
1	2	2	1
2	2	4a	2
WTR DEPLOYMENTS		3a	2
14	1	10	1
15	1	8	1
WTR RETRIEVALS		WTR DEPLOYMENTS	
12	1	5	3
13	1	WTR RETRIEVALS	
14	1	NONE REQUIRED	
15	1		

All other mission requirements in other years are accomplished.

2.2 ADDITIONAL PAYLOAD CAPTURE

The capability of the Option 2 Tug to capture missions beyond the Option 2 mission model is illustrated in Table 2-6 which indicates the mode in which the Option 2 Tug can capture various missions. The missions identified are those which are contained in the total mission model but are excluded in the Option 2 mission model.

NASA Missions 8, 10, 17 and 18 can be flown in the normal Tug single payload deployment or retrieval mode. NASA Missions 23, 23 and 24 can be flown by normal expendable Tug mode. NASA Missions 19 and 20 can be flown in the normal kick stage mode (with a Polaris kick stage). NASA missions 6 and 7 can be retrieved in a normal retrieval mode after their orbital energy has been reduced. The reduction of the orbital energy is accomplished by using the excess capability in another mission to bring the payload part way back. The mode is called the "nudge" mode. The amount of energy applied to the payload to "nudge" it down detracts from the primary mission capability. In addition, the energy necessary to move to the proper longitudinal position and rendezvous with the satellite also detracts from the primary mission. There are other difficulties in performing the mission such as the cyclic wobble of synchronous satellites over a period of time which make rendezvous costly. These factors are infinite in their variation and can only be defined when investigating specific mission profiles. Due to these factors, a limitation of 1,500 fps was estimated as a maximum which could be applied in the "nudge" mode. Where additional velocity was necesaary to bring the heavier satellites to a energy level from which they could be retrieved by the Tug, a separate Tug flight was specified (i.e., two Tug flights).

In comparing the cost of the two types of operation, it is obvious that utilizing the nudge mode saves about $11.5 million for the one flight (Shuttle and Tug operations). The costs for performing the nudge operation should include about one third of the Shuttle/Tug operations cost of the flight in question, since on the average it would reduce Tug mission capability by about one third. Thus, the net savings would be about $7 million over using the two Tug mode. However, in real operations surplus capability would probably be available on the two Tug flights that secondary mission could be performed. The conclusion appears to be that both operational modes should be available to the Tug operators.

DOD Mission 12b is performed by the Option 2 Tug in a normal round-trip mission mode as the round-trip weight capability of the Option 2 Tug is greater than 2400 pounds.

TABLE 2-6

OPTION 2

ADDITIONAL PAYLOAD CAPTURE POTENTIAL

MISSIONS EXCLUDED FROM OPTION MISSION MODE					CANDIDATE CONFIGURATION 2		
DESIGNATION		DEPLOY	RETRIEVE	SORTIE	TUG MODE		
I.D. #	WT				DEPLOY	RETRIEVE	SORTIE
N 6	5000	-	3	-		Nudge 300fps 3	
N 7	5500	-	10	-		Nudge 600 fps 10	
N 8	4000	-	7	-		Normal 7	
N 10	9500	-	2	-		Normal 2	
N 17	2000	2	-	-	Normal 2		
N 18	3300	2	-	-	Normal 2		
N 19	7900	3	-	-	Kick Stage 3		
N 20	1500	2	-	-	Kick Stage 2		
N 22	4000	4	-	-	Expendable 4		
N 23	6600	2	-	-	Expendable 2		
N 24	4400	4	-	-	Expendable 4		
D 12b	2400	-	-	4			Normal 4
TOTAL	DEPLOY	19	-	-	19	-	-
	RETRIEVE	-	22	-	-	22	-
	SORTIE	-	-	4	-	-	4
	TOTAL	45			45		

N = NASA D = DOD

2.3 FLIGHT DATA

2.3.1 Flight-by-Flight Mission Assignments

The following table (Tables 2-6) present the flight by flight mission assignments for each of the Tug flights for each year of the program. ETR and WTR launches are shown on separate pages.

Each chart shows the following data:

Flight Number - numbering of flights which is arbitrary and has no relation flight sequence or schedule.

Orbit - Mission orbit defined by altitude and inclination. In the case of interplanetary missions the mission velocity is given.

Flight Mode - the flight mode the Tug will operate to perform the mission. Flight modes used by the Option 1 Tug are defined as follows:

A	single payload deployment
A( )	multi-payload deployment
A-KL	payload deployment using kick stage (planetary mission)
A-E	payload deployment expending the Tug (planetary mission)
AB	Round-trip (single payload deployment and single payload retrieval)
A()B	Round-trip (multi-payload deployment and single payload retrieval)
BA	Sortie mission (round-trip of one payload with mission duration equal to Tug duration capability)

MISSION CAPTURE
OPTION 2

LAUNCH SITE ETR YEAR: 1984

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	AB	B	3500	4	1800
2	"	AB	B	3500	4	1800
3	"	AB	7	3000	3	2100
4	"	A(2)B	4, 1	2700	3	2100
5	"	AB	3	2100	3	2100
6	"	AB	1	900	2	1700
7	1 A.U.	A	9	1400	—	—
8	6900 / 55	A	10	6000	—	—
9	13000 fps	A	18	2000	—	—
10	"	A	18	2000	—	—
DOD FLIGHTS						
1		A(2)B	2, 2	1380	2	690
2		AB	3b	1570	3b	1570
3		AB	15	1970	15	1970
4		A(2)	17, 17	4440	—	—
5		A	4a	3480	—	—
6		A	4a	3480	—	—
7		A(2)B	3a, 3a	3140	3a	1570
8		A(2)B	3a, 3a	3140	3a	1570
9		AB	8	2430	8	2430
10		A(3)	11b, 11b, 11b	2550	—	—

MISSION CAPTURE
OPTION 2

LAUNCH SITE ETR YEAR 1985

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	AB	B	3500	1	900
2	"	AB	B	3500	2	1700
3	"	AB	7	3000	3	2100
4	"	AB	7	3000	4	1800
5	"	AB	6	2600	3	2100
6	"	AB	4	1800	5	2800
7	"	A(2)B	1, 2	2600	3	2100
8	"	AB	3	2100	3	2100
9	"	AB	3	2100	3	2100
10	"	AB	3	2100	3	2100
11	"	AB	3	2100	3	2100
12	"	AB	3	2100	5	2800
13	"	B	—	—	5	2800
14	30K x 160K/29	AB	11	1700	11	1700
DOD FLIGHTS						
1		AB	2	690	2	690
2		AB	2	690	2	690
3		AB	15	1970	15	1970
4		A	6	3480	-	-
5		A	6	3480	-	-
6		AB	4b	3480	4b	3480
7		AB	4b	3480	4b	3480
8		AB	8	2430	8	2430
9		AB	8	2430	8	2430
10		A(3)	11c, 11c, 11c	2550	-	-

MISSION CAPTURE
OPTION 2

LAUNCH SITE WTR YEAR 1985

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	VARIOUS	A(3)B	12,13,14	3800	14	800
2	700/100	AB	15	2000	15	2000
3	500/99	AB	16	4500	16	4500
4	500/99	AB	16	4500	16	4500
5	500/99	AB	16	4500	16	4500
6	500/99	AB	16	4500	16	4500
DOD FLIGHTS						
1		A(2)	16,16	5220	-	-
2		BA	12a	6000	12a	6000

MISSION CAPTURE
OPTION 2

LAUNCH SITE ETR YEAR 1986

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	AB	8	3500	1	900
2	"	AB	8	3500	1	900
3	"	AB	3	2100	4	1800
4	"	AB	3	2100	2	1700
5	"	AB	3	2100	3	2100
6	"	AB	3	2100	3	2100
7	"	AB	3	2100	3	2100
8	"	AB	1	900	2	1700
9	30K x 16K / 29	B	-	-	11	1700
10	1 A.U.	A(2)	9, 9	2800	-	-
11	16,500 fps	A-KL	19	5500	-	-
12	24000 fps	A-E	22	2500	-	-
13	18400 fps	A-KL	23	5000	-	-
14	"	A-KL	23	5000	-	-
DOD FLIGHTS						
1		AB	2	690	2	690
2		AB	2	690	2	690
3		AB	3b	1570	3b	1570
4		A	17	2220	-	-
5		AB	3a	1570	3a	1570
6		AB	3a	1570	3a	1570
7		AB	3a	1570	3a	1570
8		AB	3a	1570	3a	1570
9		AB	4b	3480	4b	3480
10		B	-	-	10	2745
11		AB	8	2430	8	2430
12		AB	8	2430	8	2430

MISSION CAPTURE
OPTION 2

LAUNCH SITE WTR YEAR. 1986

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
	NASA FLIGHTS					
1	180 x 180 / 90	B	-	-	12	2000
2	20K x 1K / 90	B	-	-	13	1000
3	300 x 300 / 90	AB	14	800	14	800
4	700 / 100	AB	15	2000	15	2000
	DOD FLIGHTS					
1		A(3)	5,5,5	2205	-	-
2		AB	16	2610	16	2610
3		AB	16	2610	16	2610
4		B	-	-	16	2610
5		B	-	-	16	2610

MISSION CAPTURE
OPTION 2

LAUNCH SITE ETR YEAR 1987

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	AB	8	3500	1	900
2	"	AB	8	3500	3	2100
3		AB	7	3000	3	2100
4		AB	7	3000	3	2100
5		A(2)	6,4	4400	-	-
6		A(2)	4,3	3900	-	-
7		A(3)	3,3,1	5100	-	-
8		A(2)	3,3	4200	-	-
9		A(2)	3,2	3800	-	-
10	6900 / 55	A	10	6000	-	-
11	300x16K/29	A	11	1700	-	-
12	16500 fps	A-KL	19	5500	-	-
13	"	A-KL	19	5500	-	-
14	24000 fps	A-E	22	2500	-	-
DOD FLIGHTS						
1		AB	2	690	2	690
2		AB	2	690	2	690
3		AB	36	1570	36	1570
4		AB	15	1970	15	1970
5		A	6	3480	-	-
6		A	4a	3480	-	-
7		A	4a	3480	-	-
8		AB	3a	1570	3a	1570
9		AB	3a	1570	3a	1570
10		AB	3a	1570	3a	1570
11		AB	3a	1570	3a	1570
12		B	-	-	4a	3480
13		B	-	-	4a	3480
14		AB	8	2430	8	2430
15		AB	8	2430	8	2430

MISSION CAPTURE
OPTION 2

LAUNCH SITE WTR YEAR 1987

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	VARIOUS	A(3)B	12, 13, 14	3800	14	800
2	700/100	AB	15	2000	15	2000
3	500/99	B	-	-	16	4500
4	"	B	-	-	16	4500
5	"	B	-	-	16	4500
6	"	B	-	-	16	4500
DOD FLIGHTS						
1		A(3)	5,5,5	2205	-	-
2		BA	12a	6000	12a	6000

MISSION CAPTURE
OPTION 2

LAUNCH SITE ETR YEAR 1988

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	AB	B	3500	2	1700
2	"	AB	B	3500	4	1800
3	"	AB	7	3000	3	2100
4	"	A(2)B	4,3	3900	4	1800
5	"	A(3)	3,3,1	5100	-	-
6	"	A(3)	3,3,1	5100	-	-
7	"	A(2)B	3,3	4200	1	900
8	1 AU	A	9	1400	-	-
9	30 K x 16K/29	B	-	-	11	1700
DOD FLIGHTS						
1		AB	2	690	2	690
2		AB	2	690	2	690
3		AB	3b	1570	3b	1570
4		AB	15	1970	15	1970
5		A	17	2220	-	-
6		AB	3a	1570	3a	1570
7		AB	3a	1570	3a	1570
8		AB	3a	1570	3a	1570
9		AB	3a	1570	3a	1570
10		AB	4b	3480	4b	3480
11		AB	4b	3480	4b	3480
12		B	-	-	10	2745
13		AB	B	2430	B	2430
14		AB	B	2430	B	2430
15		A(3)	11a, 11a, 11a	2550	-	-

MISSION CAPTURE

LAUNCH SITE WTR YEAR 1988

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	700/100	AB	15	2000	15	2000
2	1800 x 180/90	B	—	—	12	2000
3	20K x 1K/90	B	—	—	13	1000
4	300 x 3000/90	AB	14	800	14	800
DOD FLIGHTS						
1		AB	16	2610	16	2610
2		AB	16	2610	16	2610

MISSION CAPTURE
OPTION 2

LAUNCH SITE ETR YEAR 1989

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	AB	8	3500	4	1800
2	"	AB	8	3500	3	2100
3	"	AB	7	3000	3	2100
4	"	A(2)B	2,3	3800	1	900
5	"	AB	5	2800	3	2100
6	"	AB	5	2800	3	2100
7	"	AB	5	2800	3	2100
8	"	A(2)	1,3	3000	-	-
9	30K x 160K/28.5	A	11	1700	-	-
10	13000 fps	A	17	1000	-	-
11	"	A	17	1000	-	-
12	24000 fps	A-E	22	2500	-	-
13	22000 fps	A-E	24	3300	-	-
14	22000 fps	A-E	24	3300	-	-
DOD FLIGHTS						
1		AB	2	690	2	690
2		AB	2	690	2	690
3		AB	15	1970	15	1970
4		AB	17	2220	17	2220
5		B	-	-	17	2220
6		A	6	3480	-	-
7		AB	46	3480	46	3480
8		AB	8	2430	8	2430
9		AB	8	2430	8	2430
10		A(3)	11b, 11b, 11b	2550	-	-

MISSION CAPTURE
OPTION 2

LAUNCH SITE WTR YEAR: 1989

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	VARIOUS	A(3)B	12,13,14	3800	14	800
2	VARIOUS	AB	15	2000	15	2000
3	500/99	A(2)	16,16	9000	—	—
4	"	A(2)	16,16	9000	—	—
5	"	A(2)	16,16	9000	—	—
DOD FLIGHTS						
1		A(3)	5,5,5	2205	—	—
2		AB	16	2610	16	2610
3		AB	16	2610	16	2610
4		BA	12a	6000	12a	6000

MISSION CAPTURE
OPTION 2

LAUNCH SITE ETR YEAR 1990

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	AB	8	3500	1	900
2	"	AB	8	3500	1	900
3	"	AB	6	2600	3	2100
4	"	AB	6	2600	3	2100
5	"	AB	3	2100	3	2100
6	"	AB	3	2100	3	2100
7	"	AB	3	2100	3	2100
8	"	AB	1	900	2	1700
9	"	AB	1	900	4	1800
10	1 AU	A(2)	9,9	2800	-	-
11	6900 / 55	A	10	6000	-	-
12	30K × 16K / 29	B	-	-	11	1700
13	24000 fps	A-E	22	2500	-	-
DOD FLIGHTS						
1		AB	2	690	2	690
2		AB	2	690	2	690
3		AB	3b	1570	3b	1570
4		AB	15	1970	15	1970
5		AB	17	2220	17	2220
6		B	-	-	17	2220
7		A	4a	3480	-	-
8		A	4a	3480	-	-
9		B	-	-	4a	3480
10		B	-	-	4a	3480
11		AB	3a	1570	3a	1570
12		AB	3a	1570	3a	1570
13		AB	3a	1570	3a	1570
14		AB	3a	1570	3a	1570
15		AB	8	2430	8	2430
16		AB	8	2430	8	2430
17		A(3)	11c, 11c, 11c	2550	-	-

MISSION CAPTURE
OPTION 2

LAUNCH SITE WTR YEAR 1990

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
	NASA FLIGHTS					
1	1800 x 1800/90	B	–	–	12	2000
2	20K x 1K/90	B	–	–	13	1000
3	300 x 3000/90	AB	14	800	14	800
4	700/100	AB	15	2000	15	2000
	DOD FLIGHTS					
1		A3)	5,5,5	2205	–	–

2.3.2 Mission Model

The mission model for Option 2 is provided in the following table (Table 2-7). This is the mission model provided by the Government and is repeated here for completeness. The data shown on the table includes:

1. Mission Number (and DOD identification number for DOD missions)
2. Payload Weight (in pounds)
3. Payload Length and Diameter (in feet)
4. Number of mission per year (1980 through 1990) for both up payload and down payload traffic.
5. Total traffic for each payload
6. Subtotal yearly traffic for NASA and DOD
7. Total yearly traffic

TABLE 2-7

MISSION MODEL OPTION 2

		WEIGHT L / D	80	81	82	83	84	85	86	87	88	89	90	TOTALS
1		900 / 10 / 6					2 / 2	1 / 1	1 / 2	1 / 1	2 / 1	1 / 1	2 / 2	10 / 10
2		1700 / 8 / 8					3	1 / 1	2	1	1	1	1	3 / 8
3		2100 / 12 / 8					1 / 3	5 / 7	5 / 3	6 / 3	7 / 1	2 / 5	3 / 5	29 / 27
4		1800 / 10 / 14					1 / 2	1 / 1	1	2	1 / 2	1	1	5 / 8
5		2800 / 12 / 14						3				3		3 / 3
6		2600 / 12 / 8						1		1			2	4 / 0
7		3000 / 20 / 10					1	2		2	1	1		7 / 0
8		3500 / 25 / 14					2	2	2	2	2	2	2	14 / 0
9		1400 / 9 / 6					1		2		1		2	6 / 0
10		6000 / 12 / 8					1			1			1	3 / 0
11		1700 / 8 / 8						1 / 1	1	1	1	1	1	3 / 4
12		2000 / 8 / 6					1	1	1	1	1	1	1	3 / 4
13		1000 / 7 / 7					1	1	1	1	1	1	1	3 / 4
14		800 / 10 / 5					1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	7 / 7
15		2000 / 8 / 11					1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	7 / 7
16		4500 / 11 / 13						4 / 4		4		6		10 / 8

MISSION MODEL OPTION 2 (CONT.)

		WEIGHT L / D	80	81	82	83	84	85	86	87	88	89	90	TOTALS
17		1000 / 12 | 10										2		2
18		2000 / 12 | 10					2							2
19		5500 / 20 | 12							1	2				3
20		900 / 17 | 10					2							2
21		1600 / 15 | 10												0
22		2500 / 16 | 12							1	1		1	1	4
23		5000 / 17 | 12							2					2
24		3300 / 17 | 12					2					2		4
SUB-TOTAL	NASA						17 / 14	22 / 20	16 / 13	24 / 10	16 / 10	26 / 9	15 / 14	136 / 90

MISSION MODEL OPTION 2 (CONT.)

		WEIGHT L / D	80	81	82	83	84	85	86	87	88	89	90	TOTALS
25	2	690 / 12 / 5					2 / 2	2 / 2	2 / 2	2 / 2	2 / 2	2 / 2	2 / 2	14 / 14
26	3b	1570 / 15 / 5					1 / 1		1 / 1	1 / 1	1 / 1		1 / 1	5 / 5
27	15	1970 / 16 / 10					1 / 1	1 / 1		1 / 1	1 / 1	1 / 1	1 / 1	6 / 6
28	17	2200 / 12 / 10					2		1		1	1 / 2	1 / 2	6 / 4
29	12b	2400 / 20 / 10												0 / 0
30	6	3480 / 20 / 9						2		1		1		4 / 0
31	4a	3480 / 25 / 15					2 / 2			2 / 2			2 / 2	6 / 6
32	3a	1570 / 15 / 5					4 / 4		4 / 4	4 / 4	4 / 4		4 / 4	20 / 20
33	4b	3480 / 25 / 15						2 / 2	1 / 1		2 / 2	1 / 1		6 / 6
34	10	2745 / 20 / 9					1		1		1			0 / 3
35	8	2430 / 25 / 12.7					2 / 2	2 / 2	2 / 2	2 / 2	2 / 2	2 / 2	2 / 2	14 / 14
36	11a	850 / 9 / 6									3			3 / 0
37	11b	850 / 9 / 6					3					3		6 / 0
38	11c	850 / 9 / 6						3					3	6 / 0
39	5	735 / 3 / 5					3		3	3		3	3	15 / 0
40	16	2610 / 14.5 / 6.7						2	2 / 4		2 / 2	2 / 2		8 / 8
41	12a	6000 / 20 / 10						1 / 1		1 / 1		1 / 1		3 / 3
SUB-TOTAL	DOD						20 / 13	15 / 8	16 / 15	17 / 13	18 / 15	17 / 11	19 / 14	122 / 89
TOTAL							37 / 27	37 / 28	32 / 28	41 / 23	34 / 25	43 / 20	34 / 28	258 / 179

2.4 PROGRAMMATICS INPUT DATA

The following data was provided as a basic input to the programmatics studies. The first chart summarizes the total flights and hardware requirements. The second group of tables show the flight schedules and hardware requirements as a function of year. There are five tables in the group, an overall summary, NASA ETR, NASA WTR, DOD ETR and DOD WTR. These charts represent the data requirested in NASA letter PD-TUG-P(028-74). The next chart shows the same flight requirements data in the format used by MDAC in the study. The final chart shows the usage of individual Tugs to accomplish the mission model.

At the top of the chart, the number of flights per year is shown and the number of Tug expendable flights. The number of Tugs required were established by first determining the number of Tugs necessary to accomplish the 1990 requirements and working backward from that point. The maximum number of flights any Tug can perform in a year is established first by summin the Tug ground turn-around time and the mission time which results in the minimum mission turn-around time. In Option 2 the ground turn-around time is 27.9 days and the average mission time is 3.3 days. The mission turn-around time is thus 31.2. The maximum number of cycles (flights) in a year is then 11.

Using this number and assuming that the maximum number of flights than an expended Tug can make in the year that it is expended is 6 (one-half the maximum turn-around in a year), the fleet of 4 for 1990 is established. Working backward from there it can be seen that in 1989 the three expendable requirements and the necessary Tugs in 1990 make up the inventory requirement. The resulting data show that to carry-out the operations a total of 9 Tugs are required during the program.

The major influence on fleet sizing is the number of expendable Tug missions required. If, for example, no expendable missions were required the required fleet size could be reduced to three vehicles.

CONFIGURATION OPTION 2

	REQUIRED	ACCOMPLISHED
DEPLOYMENTS	258	248
RETRIEVALS	179	154
FLIGHT REQUIREMENTS (NASA/DOD)		
# ETR LAUNCHES		88/89
# WTR LAUNCH		29/16
# REFLIGHTS DUE TO LOSSES		3
FLIGHT COMPOSITION		
EXPENDABLES (E)		6
TUG WITH BURNER II (KS_1)		-
TUG WITH POLARIS (KS_2)		5
TUG (BASIC)		211
VEHICLE LOSSES/REFLIGHTS		3
		(225)
FLEET SIZE REQUIREMENTS		
FOR OPERATIONS		9
FOR RELIABILITY		3
TOTAL		12
REQUIREMENT AT IOC (MIN)		2
FLIGHTS PER ARTICLE		24.5

TURNAROUND CYCLE 31.2 DAYS LAUNCH TO LAUNCH (CALENDAR DAYS)

F L I G H T S C H E D U L E

TUG CONCEPT OPTION 2

LAUNCH SITE ETR/WTR AGENCY NASA/DOD

COMPANY MDAC

	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
TUG (BASIC)**						20	32	(1) 36	(1) 37	31	(3) 33	(1) 36	(6) 225
AUXILIARY STAGE								(3)	(2)				(5)
DROP TANKS													
(OTHER)				1*									
SHUTTLE **				1*		20	32	36	37	31	33	36	225

() DENOTES NUMBER EXPENDED.

REMARKS: 25 payloads not accommodated in 1984 due to Tug availability

* IVU test flight

** Includes reflights due to reliability losses

F L I G H T S C H E D U L E

TUG CONCEPT OPTION 2

LAUNCH SITE ETR AGENCY NASA

COMPANY MDAC

	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
TUG (BASIC)						10	14	(1) 14	(1) 14	9	(3) 14	(1) 13	(6) 88
AUXILIARY STAGE								(3)	(2)				(5)
DROP TANKS													
(OTHER)				1*									
SHUTTLE				1*		10	14	14	14	9	14	13	88

() DENOTES NUMBER EXPENDED.

REMARKS: 8 payloads not accommodated in 1984 due to Tug availability

* IVU test flight

F L I G H T S C H E D U L E

TUG CONCEPT OPTION 2

LAUNCH SITE ETR AGENCY DOD

COMPANY MDAC

	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
TUG (BASIC)						10	10	12	15	15	10	17	89
AUXILIARY STAGE													
DROP TANKS													
(OTHER)													
SHUTTLE						10	10	12	15	15	10	17	89

() DENOTES NUMBER EXPENDED.

REMARKS: 8 payloads not accommodated in 1984 due to Tug availability

F L I G H T S C H E D U L E

TUG CONCEPT OPTION 2

LAUNCH SITE WTR AGENCY NASA

COMPANY MDAC

	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
TUG (BASIC)							6	4	6	4	5	4	29
AUXILIARY STAGE													
DROP TANKS													
(OTHER)													
SHUTTLE							6	4	6	4	5	4	29

() DENOTES NUMBER EXPENDED.

REMARKS: 6 payloads not accommodated in 1984 due to Tug availability

F L I G H T S C H E D U L E

TUG CONCEPT OPTION 2

LAUNCH SITE WTR AGENCY DOD

COMPANY MDAC

	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
TUG (BASIC)							2	5	2	2	4	1	16
AUXILIARY STAGE													
DROP TANKS													
(OTHER)													
SHUTTLE							2	5	2	2	4	1	16

() DENOTES NUMBER EXPENDED.

REMARKS: 3 payloads not accommodated in 1984 due to Tug availability

FLIGHT REQUIREMENTS

OPTION 2

	80	81	82	83	84	85	86	87	88	89	90	TOTAL
ETR												
NASA					10	14	10	11	9	11	12	77
DOD					10	10	12	15	15	10	17	89
NASA EXPENDABLE					-	-	1	1	-	3	1	6
NASA KICK STAGE					-	-	3	2	-	-	-	5
DOD KICK STAGE					-	-	-	-	-	-	-	-
WTR												
NASA					-	6	4	6	4	5	4	29
DOD					-	2	5	2	2	[illegible]	1	16
TOTAL					[illegible]	8	9	8	6	[illegible]	5	45
RE FLIGHTS / LOSSES									1		1	

EQUAL USAGE SCHEDULE

OPTION 2

	80	81	82	83	84	85	86	87	88	89	90	TOTAL
NUMBER OF FLIGHTS					20	32	35	37	30	33	35	222
NUMBER OF EXPENDED TUGS							(1)	(1)		(3)	(1)	(6)
TUG ID 1					8	11	5					24
2					7	11	4	2				24
3					5	4	4	7	2	2		24
4						6	7	7	2	2		24
5							10	8	3	4		25
6							5	7	4	4	6	26
7								3	4	7	11	25
8								3	7	6	9	25
9									8	8	9	25
REFLIGHTS / LOSSES							1		1		1	3

2.5 SENSITIVITY STUDY DATA

2.5.1 Two Year Earlier IOC (December 1981)

A capture analysis was made to establish the fleet size requirements and flight schedule when the IOC is moved to December 1981. Identical ground rules to Option 2 were used to select mission combinations in the early years (see Section 2.1.2). The results are shown in the following four charts. The important impacts related to the capture analysis are that the fleet size increases by two vehicles and the total number of flights increases by 74 resulting in the accomplishment of 125 additional missions.

CONFIGURATION OPTION 2 (EARLY IOC)

	REQUIRED	ACCOMPLISHED
DEPLOYMENTS		
RETRIEVALS		
FLIGHT REQUIREMENTS (NASA/DOD)		
# ETR LAUNCHES		114/122
# WTR LAUNCH		39/21
# REFLIGHTS DUE TO LOSSES		3
FLIGHT COMPOSITION		
EXPENDABLES (E)		8
TUG WITH BURNER II (KS_1)		—
TUG WITH POLARIS (KS_2)		7
TUG (BASIC)		281
VEHICLE LOSSES/REFLIGHTS		3
		(299)
FLEET SIZE REQUIREMENTS		
FOR OPERATIONS		11
FOR RELIABILITY		3
TOTAL		14
REQUIREMENT AT IOC (MIN)		2
FLIGHTS PER ARTICLE		27

TURNAROUND CYCLE 31.2 DAYS LAUNCH TO LAUNCH (CALENDAR DAYS)

F L I G H T S C H E D U L E

TUG CONCEPT OPTION 2 (EARLY IOC)

LAUNCH SITE ETR/WTR AGENCY NASA/DOD

COMPANY MDAC

	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
TUG (BASIC) **				19	35	(2 40	0 33	(1) 35	(1) 38	30	(3) 33	(1) 36	(8) 299
AUXILIARY STAGE						(2)		(3)	(2)				(7)
DROP TANKS													
(OTHER)		1*											
SHUTTLE **		1*		19	35	40	33	35	38	30	33	36	300

() DENOTES NUMBER EXPENDED.

REMARKS: 2 payloads not accommodated in 1982 due to Tug availability schedule

* IVU test flight

** Includes reflights due to reliability losses

FLIGHT REQUIREMENTS

OPTION 2 (EARLY IOC)

	80	81	82	83	84	85	86	87	88	89	90	TOTAL
ETR												
NASA			7	11	14	14	10	11	9	11	12	99
DOD			12	14	17	10	12	15	15	10	17	122
NASA EXPENDABLE			-	-	2	-	1	1	-	3	1	8
NASA KICK STAGE			-	-	2	-	3	2	-	-	-	7
DOD KICK STAGE			-	-	-	-	-	-	-	-	-	0
TOTAL			19	25	35	24	26	29	24	24	30	236
WTR												
NASA			-	6	4	6	4	6	4	5	4	39
DOD			-	4	1	2	5	2	2	4	1	21
TOTAL			0	10	5	8	9	8	6	9	5	60
REFLIGHTS / LOSSES						1		1			1	3

EQUAL USAGE SCHEDULE

OPTION 2 (EARLY IOC)

	80	81	82	83	84	85	86	87	88	89	90	TOTAL
NUMBER OF FLIGHTS			19	35	40	32	35	37	30	33	35	296
NUMBER OF EXPENDED TUGS					(2)		(1)	(1)		(3)	(1)	(8)
TUG ID 1			10	10	6							26
2			8	10	6							24
3			1	8	9	8	2					28
4				7	10	8	1	2				28
5					9	6	4	5	2	2		28
6						10	10	4	2	2		28
7							11	10	3	4		28
8							7	8	4	4	5	28
9								5	4	7	11	25
10								3	7	6	10	26
11									8	8	9	25
REFLIGHTS / LOSSES						1		1			1	3

2.5.2 Engine Sensitivities

An estimate of the number of flights necessary to accomplish the Option 2 mission model was made. The basis of the estimate was a review of the Option 2 capture data and an estimate of the number of additional payload combinations which could be captured as a function of the vehicle capabilities. The vehicle capabilities considered are as follows:

Function	Category IV	ASE	Aerospike
Deploy	8,767	9,093	8,855
Retrieve	5,601	5,798	5,630
Round Trip	3,416	3,539	3,451

The resulting number of flights for each are (basic Option 2 requires 220):

Category IV	219
ASE	213
Aerospike	213

The fleet size does not change for any of the new engine concepts as compared with the basic Option 2 program.

MCDONNELL DOUGLAS

SPACE TUG SYSTEMS STUDY (CRYOGENIC)
SEPTEMBER DATA DUMP

VOLUME 4 Mission Accomplishment
Book 3 Option 3

SEPTEMBER 1973

PREPARED BY: SPACE TUG STUDY TEAM

APPROVED BY: L. Q. Westmoreland

L. Q. WESTMORELAND
STUDY MANAGER

PREPARED FOR NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MARSHALL SPACE FLIGHT CENTER
UNDER CONTRACT NO. NAS8-29677

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY-WEST
5301 Bolsa Avenue, Huntington Beach, CA 92647

PREFACE

This study report for the Tug Program is submitted by the McDonnell Douglas Astronautics Company (MDAC) to the Government in partial response to Contract Number NAS8-29677.

The current results of this study contract are reported in eight volumes:

Volume 1 – Summary, Program Option 1
Volume 2 – Summary, Program Option 2
Volume 3 – Summary, Program Option 3

These three summary volumes present the highlights of the comprehensive data base generated by MDAC for evaluating each of the three program options. Each volume summarizes the applicable option configuration definition, Tug performance and capabilities, orbital and ground operations, programmatic and cost considerations, and sensitivity studies. The material contained in these three volumes is further summarized in the Data Dump Overview Briefing Manual.

Volume 4 – Mission Accomplishment. (3 Books and 1 Supplement Bound Together)

This volume contains mission accomplishment analysis for each of the three program options and includes the tug system performance, mission capture, and fleet size analysis.

Volume 5 – Systems (3 Books)

This volume presents the indepth design, analysis, trade study, and sensitivity technical data for each of the configuration options and each of the Tug systems i.e., structures, thermal, avionics, and propulsion. Interface with the Shuttle and Tug payloads for each of the three options is defined.

Volume 6 – Operations (3 Books)

This volume presents the results of orbital and ground operations trades and optimization studies for each option in the form of operations descriptions, time lines, support requirements (GSE, manpower, networks, etc.), and resultant costs.

Volume 7 – Safety (3 Books)

This volume contains safety information and data for the Tug Program. Specific safety design criteria applicable to each option are determined and potential safety hazards common to all options are identified.

Volume 8 – Programmatics and Cost (3 Books)

This volume contains summary material on Tug Program manufacture, facilities, vehicle test, schedules, cost, project management SR&T, and risk assessment for each option studied.

These volumes contain the data required for the three options which were selected by the Government for this part of the study and are defined as:

A. Option 1 is a direct development program (I.O.C.: Dec 1979). It emphasizes low DDT&E cost; the deployment requirement is 3500 pounds into geosynchronous orbit, it does not have retrieval capability, and it is designed for a 36-hour mission. MDAC has also prepared data for an alternative to Option 1 which deviates from certain requirements to achieve the lowest practicable DDT&E cost.

B. Option 2 is also a direct development program (I.O.C.: 1983). It emphasizes total program cost effectiveness in addition to low DDT&E cost. The deployment requirement is 3500 pounds minimum into geosynchronous orbit and 3500 pounds minimum retrieval from geosynchronous orbit.

C. Option 3 is a phased development program (I.O.C.: 1979 phased to I.O.C. 1983). It emphasizes minimum initial DDT&E cost and low total program cost. The initial Tug capability will deploy a minimum of

3500 pounds into geosynchronous orbit without retrieval capability, however, through phased development, it will acquire the added capability to retrieve 2200 pounds from geosynchronous orbit. The impact of increasing the retrieval capability to 3500 pounds is also provided.

CONTENTS

Section 1

PERFORMANCE

1.1 PERFORMANCE GROUND RULES

The payload performance was determined using the classical impulsive velocity equation. The velocities employed were based on the three dimensional finite burning trajectory analyses performed during Task 1. Since most of the missions in the mission model did not exceed three days duration, this figure was used for establishing performance capability even though subsystems are sized for six days. A detailed simulation of the basic geosynchronous deployment mission taking into account the actual losses associated with each engine start and the velocity contributed by propellant settling forces was used to determine an equivalent specific impulse penalty of 4 seconds which was then used for all missions.

For the geosynchronous transfer, a velocity of 13972 fps was used which represents the most unfavorable situation (from a performance point of view) of no low orbit phasing being required and the resulting injection to the transfer orbit being performed with only one burn instead of two. This velocity is approximately 80 fps greater than the most favorable two burn transfer injection. For the return, a velocity of 13920 fps was used.

Option 3 is a phased developed program that starts out similar to Option 1 and develops into a vehicle similar to Option 2 but retaining the Category I RL-10. Since the Option phases into a retrieval requirement, the tankage is sized for that mission even though it initially does not have the retrieval hardware.

The following weights and engine data were also employed in the performance computations:

	Initial	Final
Shuttle Capability	65,000	65,000
Ancillary equipment (to install Tug in the Orbiter Bay)	2,066	2,066
Vented during ascent	269	269
Tug gross weight at deployment from Orbiter Bay	62,665	62,665
Tug burnout weight (included FPR)	7,315	7,039
Propellant capacity (@5.5 EMR)	55,600	55,600

	Initial	Final
Engine chilldown and propellant settling	61	61
Vented in flight	57	57
Attitude control propellant	93	93
Engine	Category I RL-10	
Thrust	15,000	
ISP (@ 5.5:1 EMR)	441.8	

1.2 GEOSYNCHRONOUS PERFORMANCE

Based on the foregoing ground rules and data, the following geosynchronous orbit performance capabilities were determined at the nominal 5.5:1 EMR:

	Initial	Final
Deployment	3588 (3780)	4330 (4522)
Retrieval	--	2567
Round Trip	1335 (1366)	1611 (1642)

The deployment and round trip missions would require propellant to be off-loaded. By off-loading LOX only, an engine mixture ratio of 5.0 could be used yielding a two second improvement in Isp for deployment or 5.3 and 0.8 seconds for round trip and the payloads shown in parentheses. For mission of greater than 36 hours, the increase in on-orbit consumables must be corrected for using the factors given in Section 1.4.2. The final configuration would also have longer duration capability which would allow use of the lower velocity three burn transfer. But for a three day duration, the 150 lb added losses in geosynchronous orbit would leave a net difference of only 15 lb less deployment payload capability. Figure 1.2-1 shows how the payload delivery capability decreases as payload is returned.

1.3 PERFORMANCE ENVELOPE

Figures 1.3-1, -2 and -3 present the payload-velocity envelope for the Option 3I Tug starting from 28.5°, 55° and 90° inclinations, respectively. The corresponding data for Option 3f follows in figures 1.3-4, -5, and -6. The significant variation with inclination reflects the Shuttle performance with launch azimuth. For missions below geosynchronous, specific impulse could be increased by off-loading LOX only initially to reduce the EMR to 5.0 and gain up to two seconds.

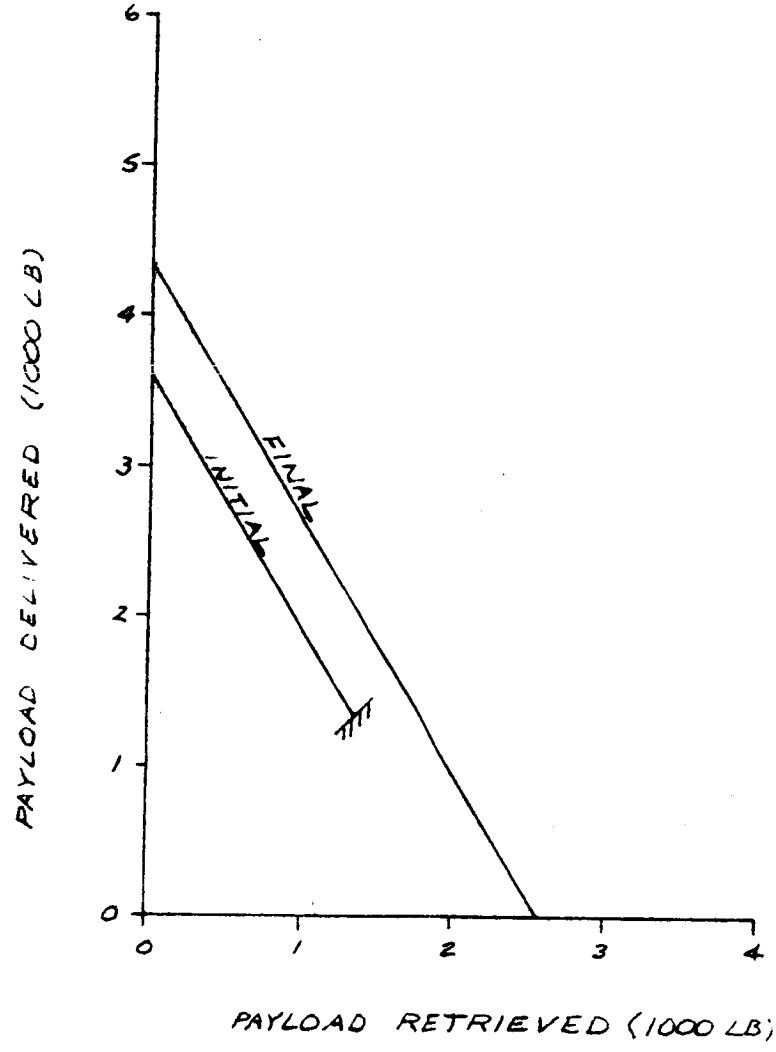
DOUGLAS

PREPARED BY: SPT MODEL REPORT NO. REVISED

REFERENCE PAGE NO. DATE

GEOSYNCHRONOUS PERFORMANCE

CONFIGURATION OPTION 3



PERFORMANCE CAPABILITY

CONFIGURATION 3I

W_{BO} 7315

I_{SP} 441.8

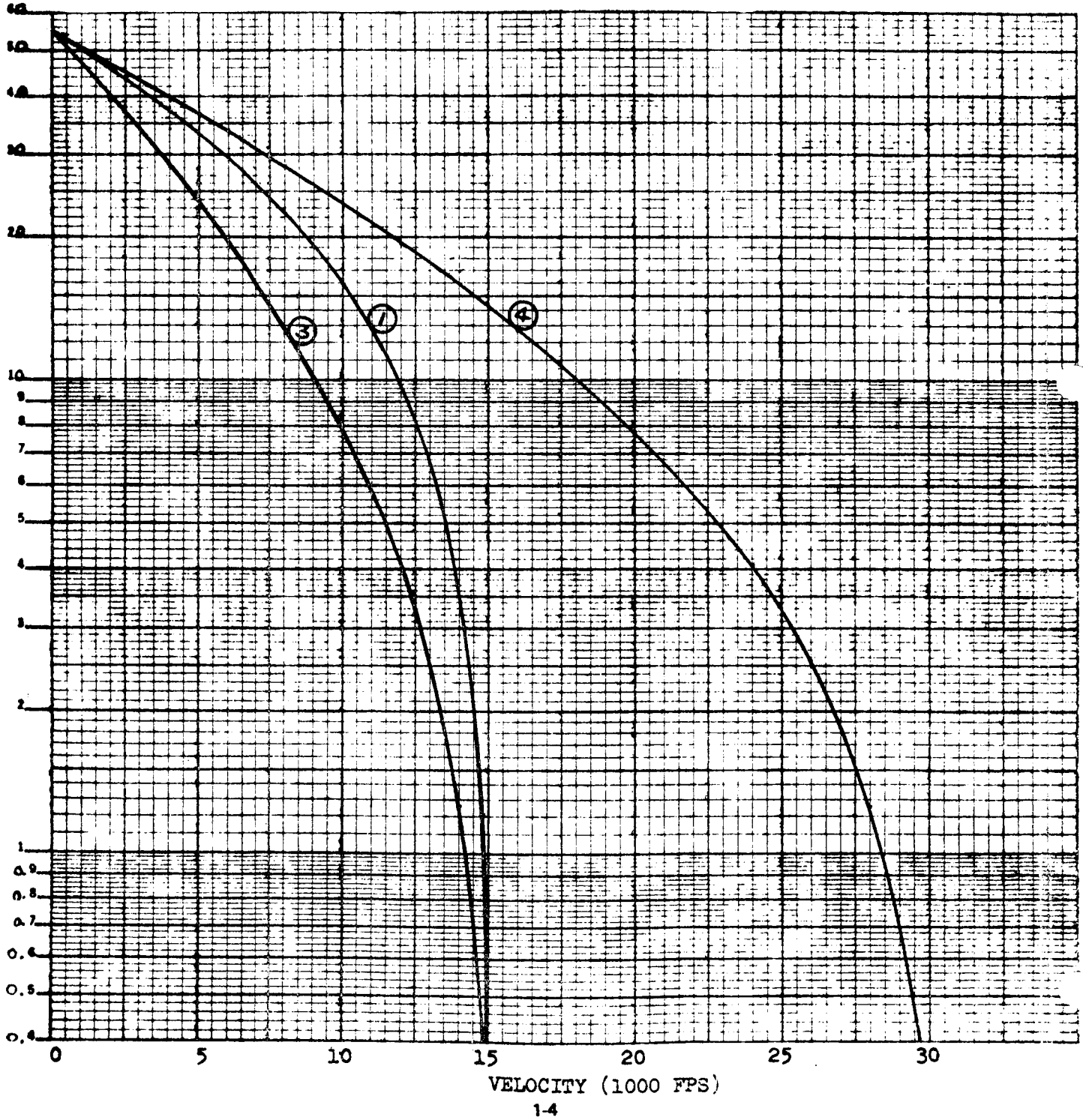
INCL 28.5°

① DEPLOY

② RETRIEVE

③ ROUND TRIP

④ EXPENDABLE



PERFORMANCE CAPABILITY

CONFIGURATION 31

W_{BO} 7315

I_{SP} 441.5

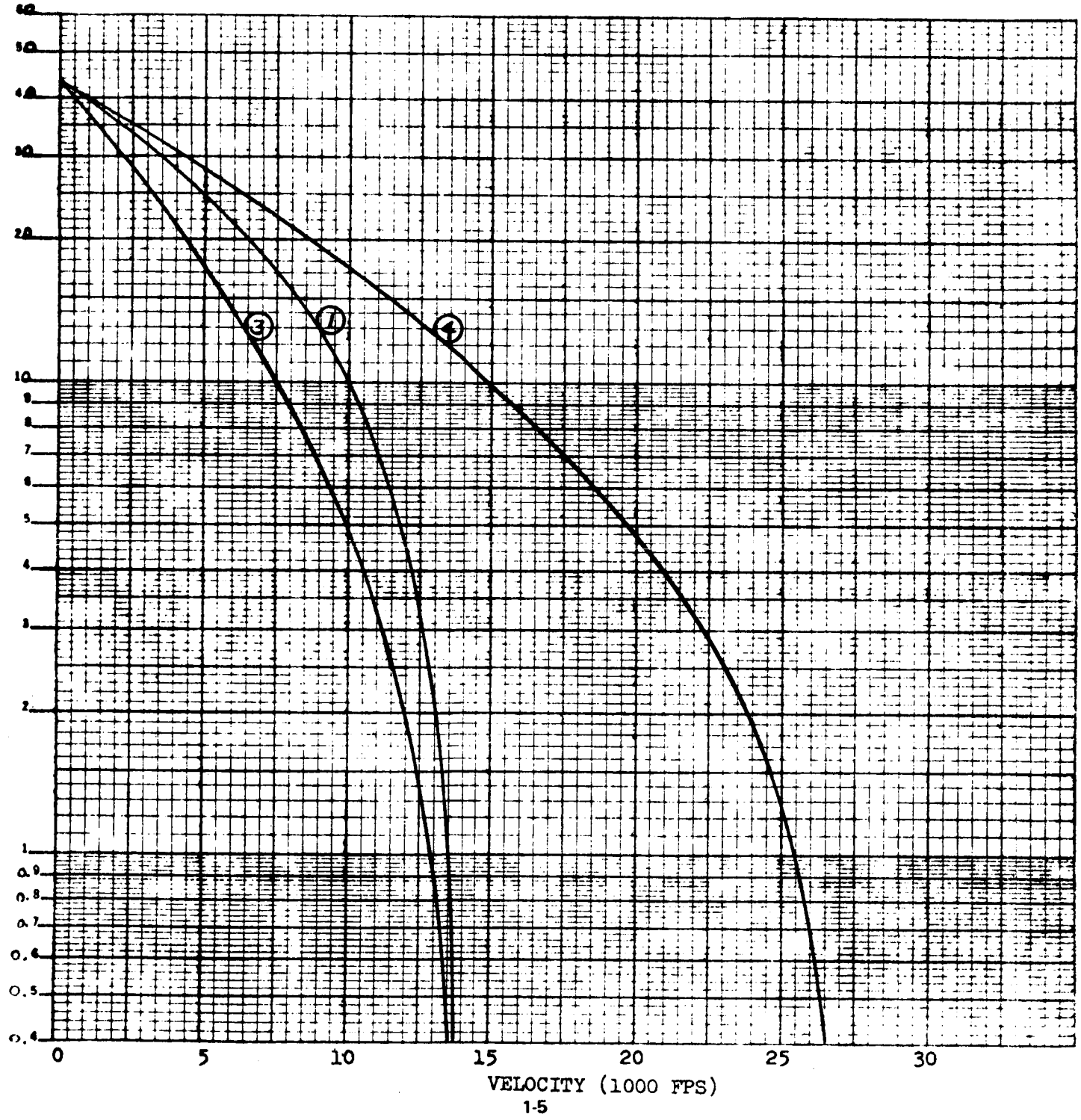
INC 55°

① DEPLOY

② RETRIEVE

③ ROUND TRIP

④ EXPENDABLE



PERFORMANCE CAPABILITY

CONFIGURATION 3E

W_{BO} 7315

I_{SP} 4418

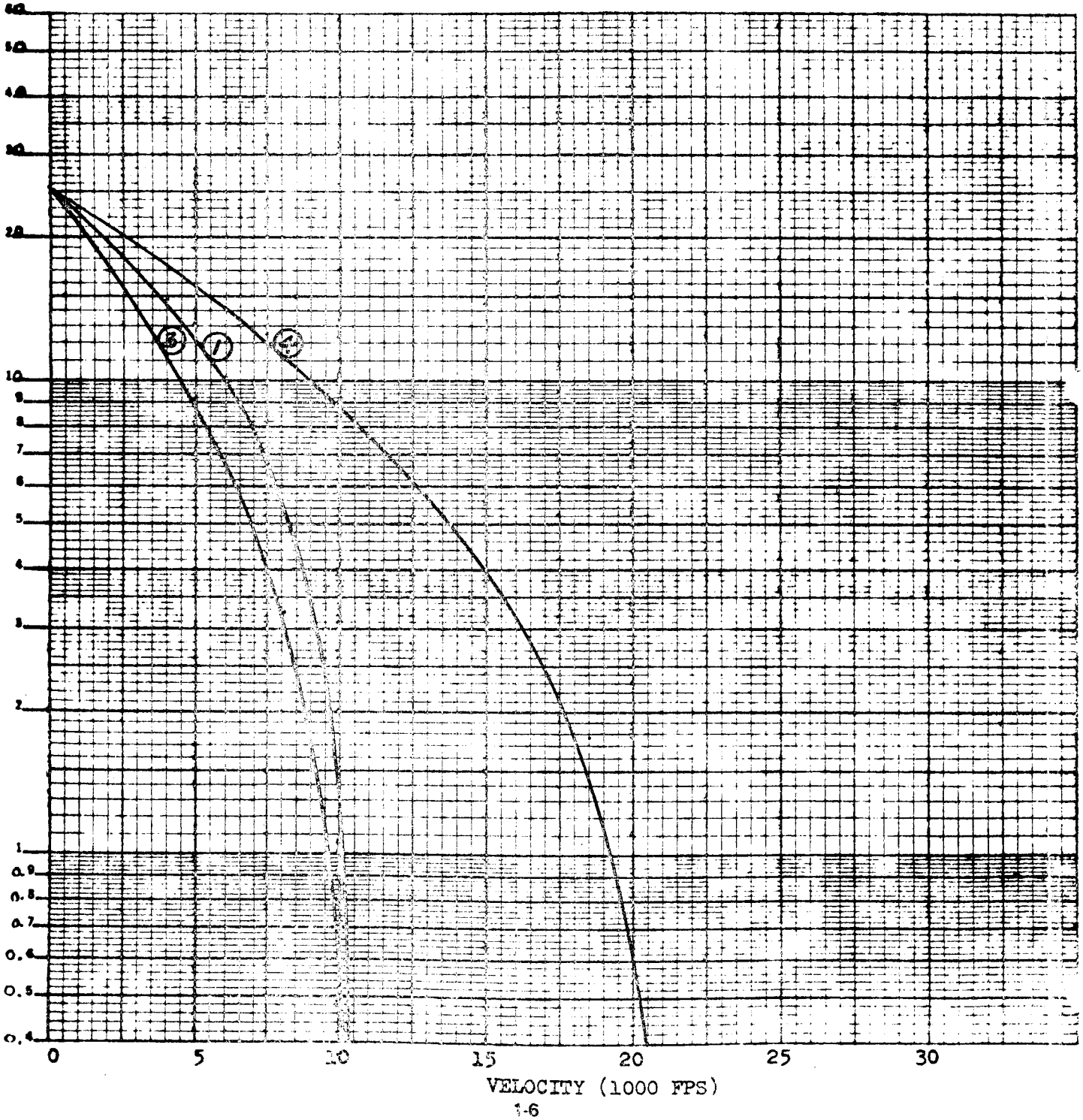
INCL 90°

① DEPLOY

② RETRIEVE

③ ROUND TRIP

④ EXPENDABLE



PERFORMANCE CAPABILITY

CONFIGURATION 3F

W_{BO} 7039

I_{SP} 441.8

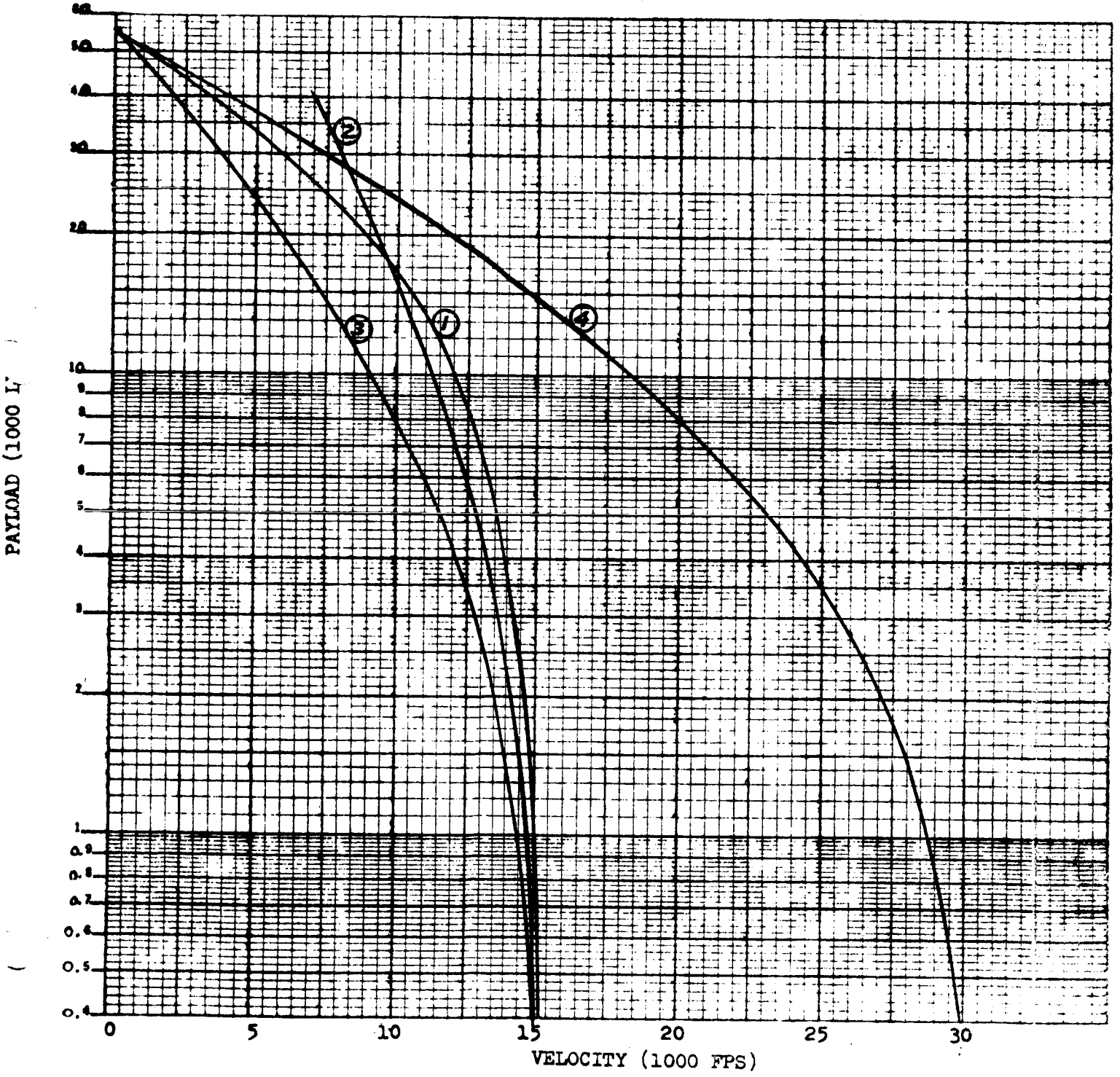
INCL 28.5°

① DEPLOY

② RETRIEVE

③ ROUND TRIP

④ EXPENDABLE



PERFORMANCE CAPABILITY

CONFIGURATION 3F

W_{BO} 7039

I_{SP} 4418

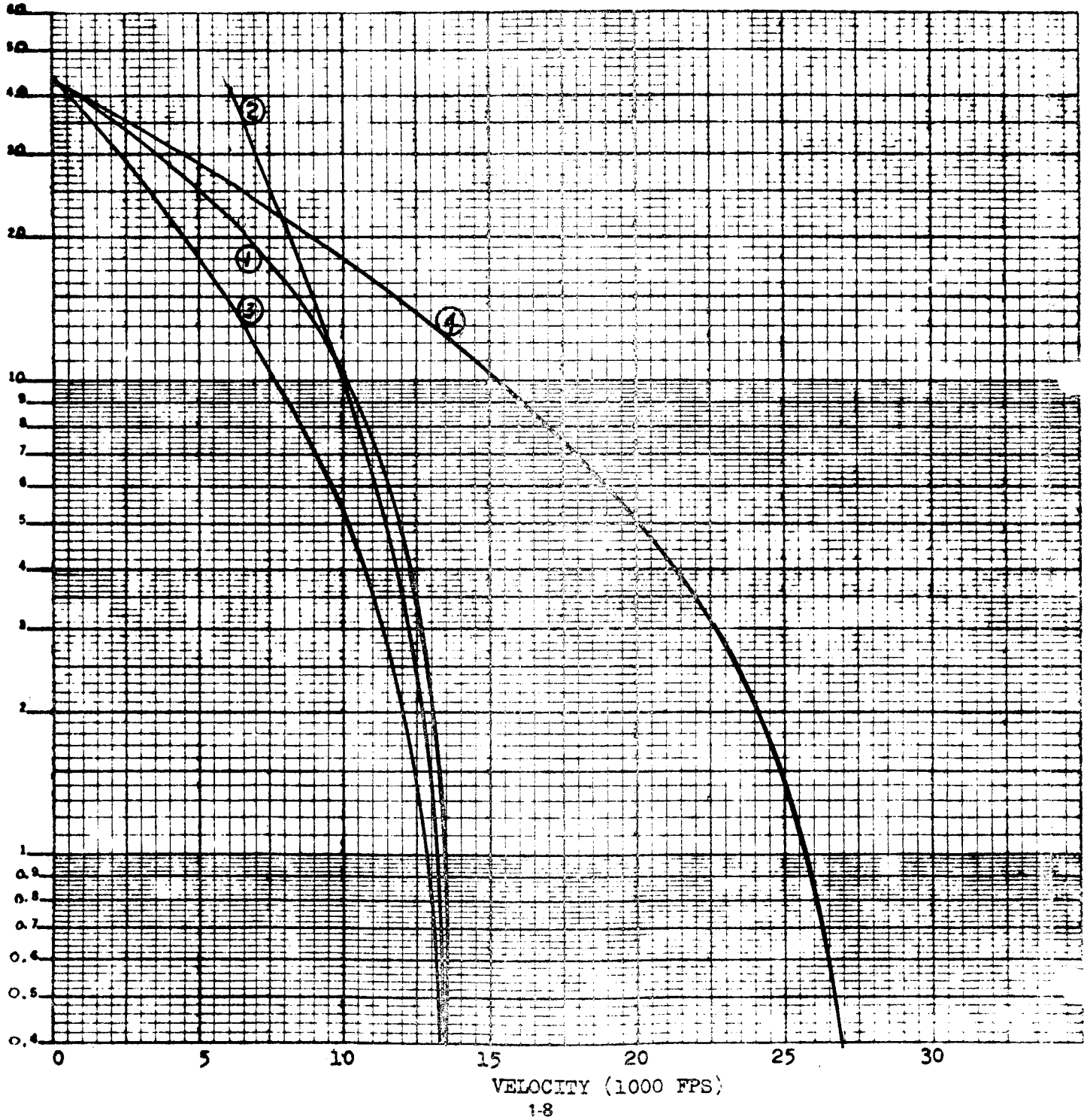
INCL 55°

① DEPLOY

② RETRIEVE

③ ROUND TRIP

④ EXPENDABLE



PERFORMANCE CAPABILITY

CONFIGURATION 3F

W_{BO} 7039

I_{SP} 441.8

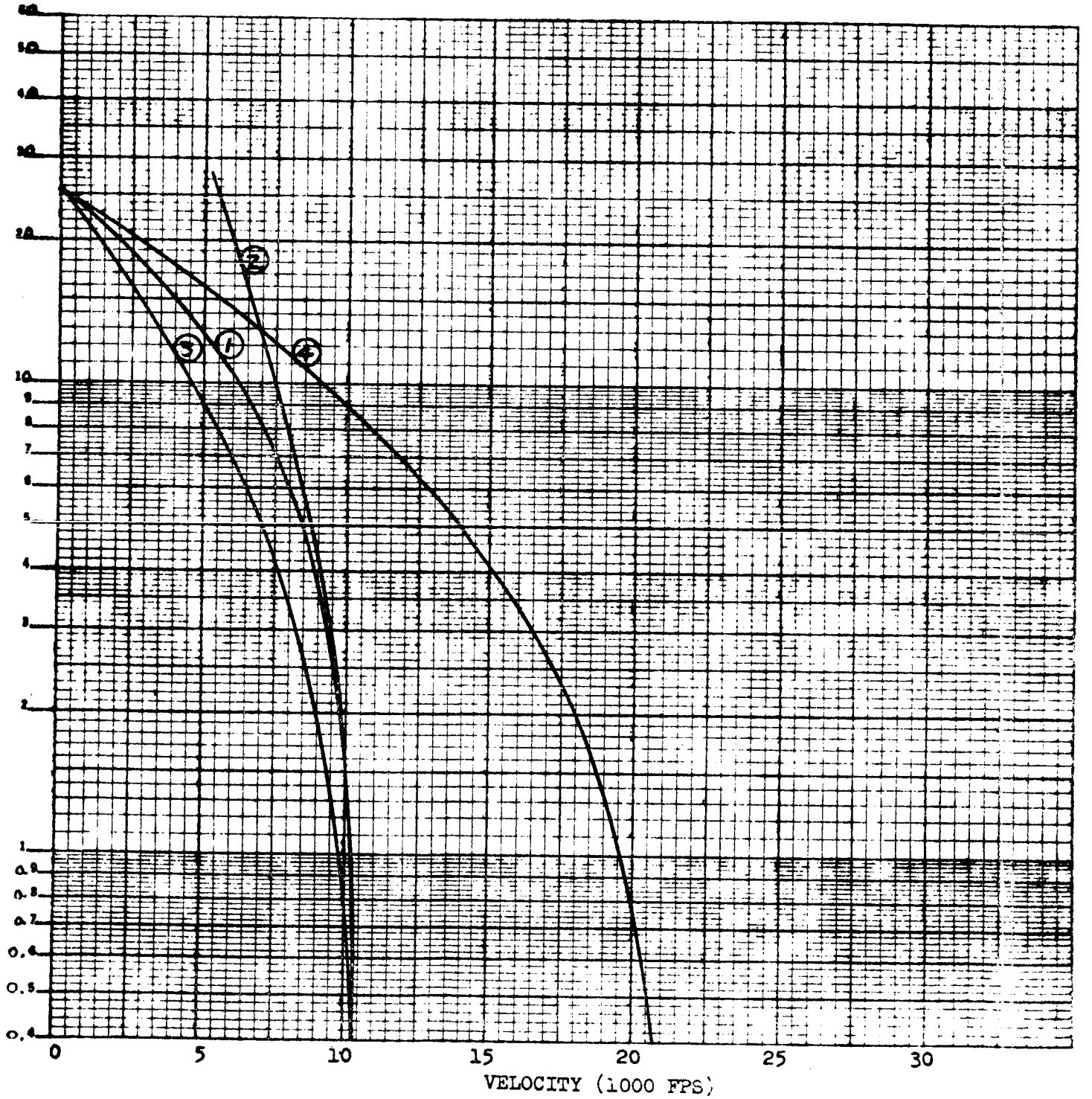
INCL 90°

① DEPLOY

② RETRIEVE

③ ROUND TRIP

④ EXPENDABLE



1.4 PERFORMANCE SENSITIVITIES

1.4.1 General Mission Trade Factors

The sensitivity of payload to the two principle performance factors, -Tug inert weight and Isp - are presented as a function of mission velocity in Figure 1.4-1.

1.4.2 Geosynchronous Trade Factors

Specific trade factors for the geosynchronous missions are given in Table 1.4-1. The inert weight factor is applicable to any weight carried throughout the mission, such as structure and residual propellants. The gross weight factor can correct for variations in the Tug gross weight at first ignition such as Shuttle capability, ancillary equipment or propellants vented during ascent. These factors can be used for both initial and final configurations.

1.5 MISSION PERFORMANCE

The performance capability for each mission in the mission model was computed for each basic mission mode. The missions are defined in Table 1.5-1. Table 1.5-2 and -3 are computer printouts of the results for the initial and final configurations respectively and includes the velocities derived from Task I. The gross weight reflects the Shuttle delivery capability to the appropriate parking orbit inclinations. In several cases, alternate mission profiles are shown starting from different inclinations.

For the Option 3I vehicle, retrieval capabilities are shown even though the equipment necessary to physically pick up or attach such a payload is not included in the Tug weight shown. The capabilities with a kick stage were also determined for use in the mission capture analysis but are not shown simply to avoid classifying any data.

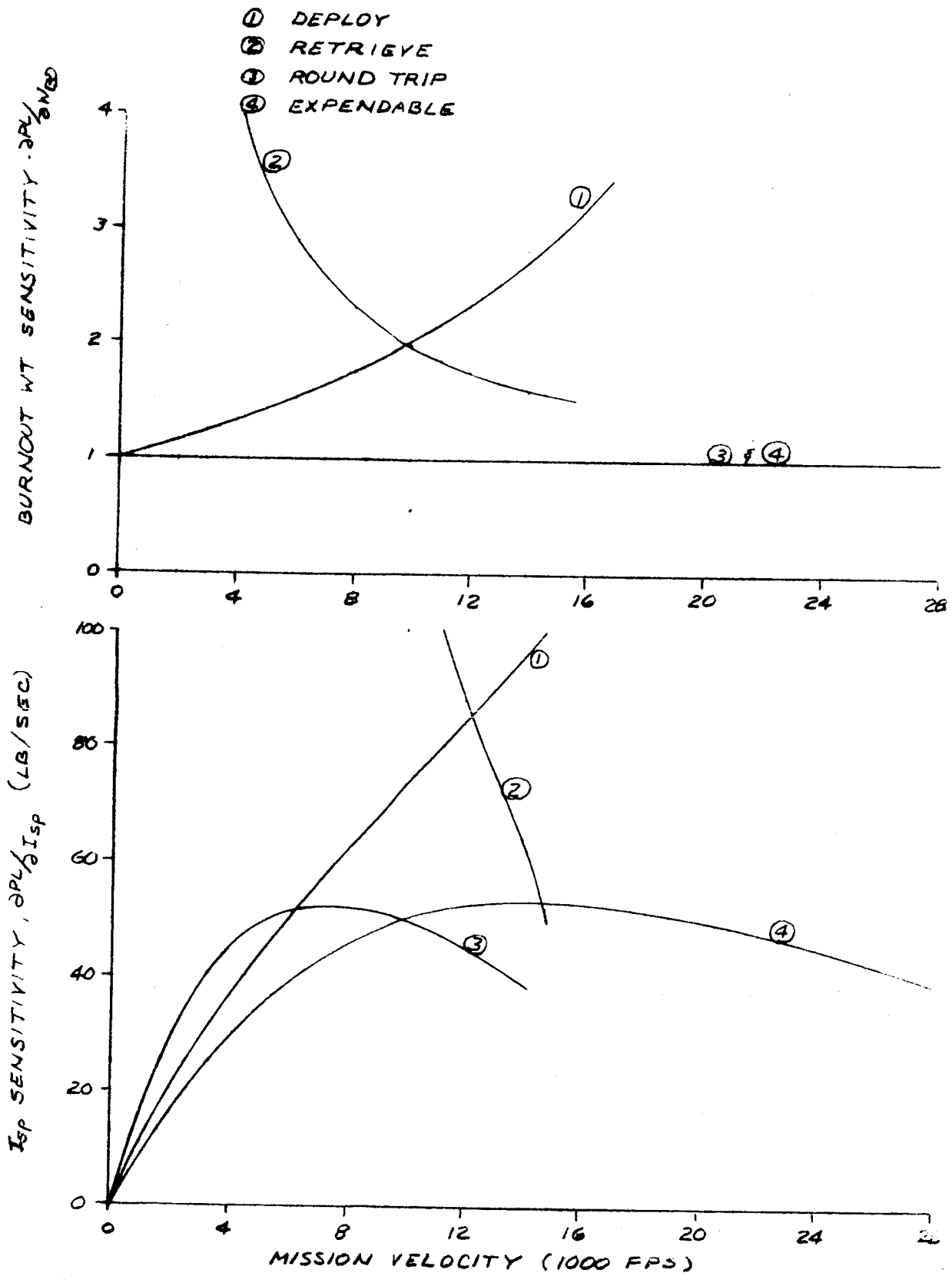
DOUGLAS

PREPARED BY: _____ MODEL _____ REPORT NO. _____ REVISED _____

REFERENCE _____ PAGE NO. _____ DATE _____

PERFORMANCE SENSITIVITY

CONFIGURATION OPTION 3



FORM 28-BP-4G (REV. 6-71)

GEOSYNCHRONOUS MISSION TRADE FACTORS

	DEPLOY	RETRIEVE	ROUND TRIP
Burnout Weight: $\partial PL/\partial W_{BO}$	-2.67	-1.60	-1
Specific Impulse: $\partial PL/\partial I_{SP}$	95	64	39
Gross Weight: $\partial PL/\partial W_0$	.37	.22	.14
Orbit Loss: $\partial PL/\partial W_{OL}$	-1	-.60	-.37

Table 1.5-1

MISSION DESCRIPTIONS

Mission No.	H_a x H_p (nmi)	Incl.	Remarks
1-8	19323	0	Synchronous orbit - single burn transfer orbit injection
1-8A	19323	0	Synchronous orbit - two burn transfer injection
1-8B	19323	0	Synchronous orbit - two burn transfer injection with 600 fps for multiple payload deployments
9	1AU	Eclip.	
10	6900	55°	
10A	6900	55°	Alternate - Shuttle launched into 28.5°
11	16Kx30K	20°	
12	180x1800	90°	
13	1Kx20K	90°	
13A	1Kx20K	90°	ETR Alternate - Shuttle launched into 28.5°
13B	1Kx20K	90°	ETR Alternate - Shuttle launched into 55°
14	300x3000	90°	
15	700	100°	
16	500	99.2°	
17-8	Interplanetary		ΔV - 13000
19			16500
20			23000
21-2			24000
23			18400
24			22000
D11	58K	0,30,60	
D10	860x21K	63.4	Shuttle launch into 63.4° WTR
D10A	860x21K	63.4	ETR Alternate - Shuttle launched into 55°
D5	750	99°	
D3	13.6Kx25K	60°	Shuttle launched into 60° WTR
D3A	13.6x25K	60°	ETR Alternate - Shuttle launched into 55°
D12	300	104°	
D16	400	98.3°	

CØNFIGURATIØN ØPT 3I STAGE WT=7315.00 ISP=441.80 DELISP=4.00

MISSIØN	GRØSS-WT V-ØUT	PL-RØUND V-BACK	PL-DEPLØY	PL-RETRIEVE	PL-EXPEND
1-8	62665.00 13972.00	1335.76 13920.00	3588.51	2127.81	15925.11
1-8A	62665.00 13890.00	1386.27 13920.00	3724.20	2208.27	16060.79
1-8B	62665.00 14190.00	1023.42 14220.00	2808.60	1610.15	15568.22
9	62665.00 14160.00	964.44 14350.00	2671.27	1509.40	15617.01
10	50665.00 9700.00	5465.99 9700.00	10882.80	10981.61	18131.98
10A	62665.00 12760.00	2922.37 12760.00	7230.27	4904.86	18013.35
11	62665.00 12450.00	3383.05 12450.00	8187.84	5765.07	18576.96
12	32665.00 2285.00	16299.57 2285.00	19170.24	108848.31	20458.55
13	32665.00 8400.00	2595.66 8400.00	4712.36	5778.68	10677.55
13A	62665.00 13460.00	1953.80 13460.00	5080.21	3174.80	16785.40
13B	50665.00 11200.00	3014.24 11200.00	6675.72	5495.66	15561.43
14	32665.00 3600.00	12277.56 3600.00	15852.87	54438.61	17983.04
15	26665.00 1700.00	13631.58 1700.00	15380.14	119901.62	16318.46
16	26665.00 1120.00	15429.58 1120.00	16706.52	201869.75	17311.90
17-8	62665.00 13140.00	2309.20 13250.00	5915.44	3787.85	17339.18
19	62665.00 16740.00	.00 17210.00	.00	.00	11778.93

20	62665.00 23550.00	.00 24500.00	.00	.00	4459.11
21-2	62665.00 24600.00	.00 25500.00	.00	.00	3613.35
23	62665.00 18720.00	.00 19550.00	.00	.00	9275.04
24	62665.00 22500.00	.00 23500.00	.00	.00	5370.34
D11	62665.00 13930.00	1355.44 13930.00	3643.95	2158.24	15994.50
D10	48665.00 8500.00	7241.95 8500.00	13241.24	15983.95	19301.04
D10A	50665.00 9800.00	5285.80 9800.00	10599.03	10544.33	17951.97
D5	26665.00 1770.00	13424.42 1770.00	15221.87	113686.00	16201.30
D3	48665.00 11850.00	1731.80 11850.00	4016.62	3044.46	13667.44
D3A	50665.00 11920.00	2010.46 11920.00	4686.13	3521.09	14421.47
D12	26665.00 500.00	17522.61 500.00	18155.77	502460.00	18420.09
D16	26665.00 850.00	16318.48 850.00	17333.52	278667.12	17788.52

CØNFIGURATIØN ØPT 3F STAGE WT=7039.00 ISP=441.80 DELISP=4.00

MISSIØN	GRØSS-WT V-ØUT	PL-RØUND V-BACK	PL-DEPLØY	PL-RETRIEVE	PL-EXPEND
1-8	62665.00 13972.00	1611.76 13920.00	4329.98	2567.46	16201.11
1-8A	62665.00 13890.00	1662.27 13920.00	4465.66	2647.92	16336.79
1-8B	62665.00 14190.00	1299.42 14220.00	3566.03	2044.38	15844.22
9	62665.00 14160.00	1240.44 14350.00	3435.72	1941.36	15893.01
10	50665.00 9700.00	5741.99 9700.00	11432.32	11536.12	18407.98
10A	62665.00 12760.00	3198.37 12760.00	7913.12	5368.09	18289.35
11	62665.00 12450.00	3659.05 12450.00	8855.83	6235.41	18852.96
12	32665.00 2285.00	16575.57 2285.00	19494.85	110691.44	20734.55
13	32665.00 8400.00	2871.66 8400.00	5213.43	6393.13	10953.55
13A	62665.00 13460.00	2229.80 13460.00	5797.86	3623.29	17061.40
13B	50665.00 11200.00	3290.24 11200.00	7286.98	5998.87	15837.43
14	32665.00 3600.00	12553.56 3600.00	16209.24	55662.39	18259.04
15	26665.00 1700.00	13907.58 1700.00	15691.55	122329.31	16594.46
16	26665.00 1120.00	15705.58 1120.00	17005.36	205480.75	17587.90
17-8	62665.00 13140.00	2585.20 13250.00	6622.46	4240.58	17615.18
19	62665.00 16740.00	.00 17210.00	.00	.00	12054.93

20	62665.00 23550.00	.00 24500.00	.00	.00	4735.11
21-2	62665.00 24600.00	.00 25500.00	.00	.00	3889.35
23	62665.00 18720.00	.00 19550.00	.00	.00	9551.04
24	62665.00 22500.00	.00 23500.00	.00	.00	5646.34
D11	62665.00 13930.00	1631.44 13930.00	4385.95	2597.71	16270.50
D10	48665.00 8500.00	7517.95 8500.00	13745.88	16593.12	19577.04
D10A	50665.00 9800.00	5561.80 9800.00	11152.46	11094.91	18227.97
D5	26665.00 1770.00	13700.42 1770.00	15534.83	116023.31	16477.30
D3	48665.00 11850.00	2007.80 11850.00	4656.75	3529.66	13943.44
D3A	50665.00 11920.00	2286.46 11920.00	5329.45	4004.47	14697.47
D12	26665.00 500.00	17798.61 500.00	18441.75	510374.31	18696.09
D16	26665.00 850.00	16594.48 850.00	17626.68	283380.31	18064.52

Section 2

CAPTURE ANALYSIS - OPTION 3

2.1 FLIGHT SUMMARY

The data provided in Section 2.1.1 represents a summary of the mission captured by the Option 3 program based upon all constraints of the system potential (Tug capability) and the program schedule (Tug and related support systems availability). Section 2.1.2 identified the missions, from the Option Mission Model, which are not captured by the program and also includes the rationale for their exclusion.

2.1.1 Flight Summary Data

Tables 2-1 through 2-5 present the number of flights per year for each of the flight modes used in Option 3. Also shown are the total Shuttle and Tug flights and the number of missions identified as requirements in the Option Mission Model. On Table 2-1 the number of missions accomplished is identified.

The mission modes used in this option are defined as follows:

Deploy

Single Payload - The deployment of one payload to one location and velocity vector and return of the Tug to the Shuttle.

Multi - 2 Payload - The deployment of two payloads to one location and velocity vector and return of the Tug to the Shuttle.

Multi - 3 Payloads - The deployment of three payloads to one location and velocity vector and return to the Shuttle.

Kick Stage - Large - The deployment of one or more payloads to one location and velocity vector using a Polaris kick stage as a second stage to the Tug. The kick stage is expended and the Tug returns to the Shuttle.

Expendable - The deployment of one payload to one location and velocity vector. The Tug is expended.

Retrieval

Single Payload - The retrieval of one payload from one location and return to the Shuttle.

Round Trip

Deploy 1/Retrieve 1 - Deploy one payload at one location and velocity vector (maneuver 60° phase angle position for synchronous equatorial mission between deployment and retrieval), retrieve one payload and return to the Shuttle.

Deploy Multi/Retrieve 1 - Deploy one payload at one location and velocity vector, maneuver to a second position and velocity vector and deploy second payload, if three satellites are to be deployed, maneuver to a third position and velocity vector and deploy third satellite and retrieve another satellite at that position (for synchronous equatorial mission each maneuver shall be 60° phase angle).

Sortie - Carry a payload to one orbital location, remain in that orbit for 130 hours (22 hours for initial configuration) and return the payload to the Shuttle.

FLIGHT SUMMARY-OPTION TOTAL-OPTION 3

Flight Mode		Calendar Year											Total
		80	81	82	83	84	85	86	87	88	89	90	
Totals	Shuttle	3	21	22	36	44	41	41	40	37	41	40	366
	Tug	3	21	22	36	44	41	41	40	37	41	40	366
Tug Flight Distribution	Deploy												
	Single Payload	2	21	18	25	12	14	7	10	7	12	10	138
	Multi--2 Payloads	1		2	8		1	1	5	4	4	1	27
	Multi--3 Payloads				1	2	1	1	1	1	2	2	11
	Kick-Stage Mode			2	1	2		3	2				10
	Expendable					2		1	1		3	1	8
	Retrieve												
	Single Payload					12	9	12	8	9	8	11	69
	Round Trip												
	Deploy 1/Retrieve 1					13	14	16	11	16	10	15	95
	Deploy Multi/Retrieve 1					1	1		1		1		4
	Sortie				1		1		1		1		4
Mission Model	Total												
	Deploy	34	23	24	48	37	37	32	41	34	43	34	387
	Retrieve	0	0	0	1	25	25	28	21	25	20	26	171
	Total	34	23	24	49	62	62	60	62	59	63	60	558
Accomplishment	Total	3	21	24	49	62	62	60	62	59	63	60	525

FLIGHT SUMMARY—NASA-OPTION 3

Flight Mode		Calendar Year											Total
		80	81	82	83	84	85	86	87	88	89	90	
Totals	Shuttle	3	14	12	19	26	28	24	24	19	25	22	216
	Tug	3	14	12	19	26	28	24	24	19	25	22	216
Tug Flight Distribution	Deploy												
	Single Payload	2	14	10	15	7	11	6	6	5	9	6	91
	Multi--2 Payloads	11			4			1	5	4	4	1	20
	Multi--3 Payloads												
	Kick-Stage Mode			2		2		3	2				9
	Expendable					2		1	1		3	1	8
	Retrieve												
	Single Payload					10	8	9	7	7	5	8	54
	Round Trip												
	Deploy 1/Retrieve 1					4	8	4	2	3	3	6	30
	Deploy Multi/Retrieve 1					1	1		1		1		4
	Sortie												
Mission Model	Total												
	Deploy	14	16	12	23	17	22	16	24	16	26	15	201
	Retrieve	0	0	0	0	14	17	13	10	10	9	14	87

FLIGHT SUMMARY—DOD—OPTION 3

Flight Mode		Calendar Year											Total
		80	81	82	83	84	85	86	87	88	89	90	
Totals	Shuttle	0	7	10	17	18	13	17	16	18	16	18	150
	Tug	0	7	10	17	18	13	17	16	18	16	18	150
Tug Flight Distribution	Deploy												
	Single Payload		7	8	10	5	3	1	4	2	3	4	47
	Multi--2 Payloads			2	4		1						7
	Multi--3 Payloads				1	2	1	1	1	1	2	2	11
	Kick-Stage Mode				1								1
	Expendable												
	Retrieve												
	Single Payload					2	1	3	1	2	3	3	15
	Round Trip												
	Deploy 1/Retrieve 1					9	6	12	9	13	7	9	65
	Deploy Multi/Retrieve 1												
	Sortie				1		1		1		1		4
Mission Model	Total												
	Deploy	20	7	12	25	20	15	16	17	18	17	19	186
	Retrieve	0	0	0	1	11	8	15	11	15	11	12	84

FLIGHT SUMMARY—ETR—OPTION 3

Flight Mode		Calendar Year											Total
		80	81	82	83	84	85	86	87	88	89	90	
Totals	Shuttle	3	21	22	28	39	33	32	32	31	32	35	308
	Tug	3	21	22	28	39	33	32	32	31	32	35	308
Tug Flight Distribution	Deploy												
	Single Payload	2	21	18	25	12	14	7	10	7	12	10	138
	Multi--2 Payloads	1		2	2				5	4	1	1	17
	Multi--3 Payloads					1	1			1	1	1	5
	Kick-Stage Mode			2	1	2		3	2				10
	Expendable					2		1	1		3	1	8
	Retrieve												
	Single Payload					10	9	8	4	7	8	9	55
	Round Trip												
	Deploy 1/Retrieve 1					11	9	12	10	12	7	13	74
	Deploy Multi/Retrieve 1					1							1
	Sortie												
Mission Model	Total												
	Deploy	34	23	24	32	32	23	25	33	30	27	29	312
	Retrieve	0	0	0	0	23	18	20	14	19	15	22	131

FLIGHT SUMMARY—WTR—OPTION 3

Flight Mode		Calendar Year											Total
		80	81	82	83	84	85	86	87	88	89	90	
Totals	Shuttle	0	0	0	8	5	8	9	8	6	9	5	58
	Tug	0	0	0	8	5	8	9	8	6	9	5	58
Tug Flight Distribution	Deploy												
	Single Payload												
	Multi--2 Payloads				6		1				3		10
	Multi--3 Payloads				1	1		1	1		1	1	6
	Kick-Stage Mode												
	Expendable												
	Retrieve												
	Single Payload					2		4	4	2		2	14
	Round Trip												
	Deploy 1/Retrieve 1					2	5	4	1	4	3	2	21
	Deploy Multi/Retrieve 1						1		1		1		3
	Sortie				1		1		1		1		4
Mission Model	Total												
	Deploy	0	0	0	16	5	14	7	8	4	16	5	75
	Retrieve	0	0	0	1	2	7	8	7	6	5	4	40

2.1.2 Missions Not Captured

The availability of the Shuttle in 1980 of 3 Tug flights and in 1981 of 21 flights constrains the Tug mission assignments in these years. The following rationale was used to select payloads for each of the Tug flights in those years.

1980

1. The first flight would be a simple flight with a light payload (although large enough to warrant use of the STS). NASA Mission 4 was selected.
2. The second flight would be a simple flight with a heavy payload. NASA Mission 8 was selected.
3. The third flight would be one of the most numerous. NASA Mission 3 was selected.

1981

1. Delete missions which could be performed with current expendable launch vehicles. NASA Mission 1 (two payloads) were deleted.

The following missions were not performed in 1980:

NASA		DOD	
MISSION	NUMBER OF PAYLOADS	MISSION	NUMBER OF PAYLOADS
1	2	2	2
2	1	3b	1
3	2	15	1
6	1	3a	4
7	1	4b	1
8	1	8	2
9	1	11a	3
11	1	11b	3
17	1	11c	3

Two NASA Mission 1 payloads were not performed in 1981.

All other missions, both NASA and DOD, were performed as required.

2.2 ADDITIONAL PAYLOAD CAPTURE

The capability of the Option 3 Tug to capture missions beyond the Option 3 mission model is illustrated in Table 2-6, which indicates the mode in which the Option 3 Tug can capture various missions. The missions identified are those which are contained in the total mission model, but are excluded in the Option 3 mission model.

NASA missions 17 and 18 can be deployed in the normal Tug reusable deployment mode. NASA missions 19, 22, 23, and 24 can be performed by expending the Tug. NASA mission 20 can be accomplished in a Tug reusable mode using a kick stage (Polaris Kick stage). NASA mission 5 can be retrieved in a normal retrieval mode after the orbital energy has been reduced. The reduction of the orbital energy is accomplished by using the excess capability in another mission to bring the payload part way back. The mode is called the "nudge" mode. NASA missions 6, 7, 8, and 10 require two flights to accomplish, as they are just beyond the estimated performance maximum for the "nudge" mode (see Book 2 Section 2.2.).

DOD mission 12B cannot be performed by the Option 3 Tug due to payload round trip weight capability being less than 2400 pounds.

OPTION 3

ADDITIONAL PAYLOAD CAPTURE POTENTIAL

MISSIONS EXCLUDED FROM OPTION MISSION MODE					CANDIDATE CONFIGURATION 3		
DESIGNATION		DEPLOY	RETRIEVE	SORTIE	TUG MODE		
I.D. #	WT				DEPLOY	RETRIEVE	SORTIE
N 5	2800	-	3	-		Nudge 1160 fps 3	
N 6	5000	-	3	-		Two Flights 3	
N 7	5500	-	10	-		Two Flights 10	
N 8	4000	-	7	-		Two Flights 7	
N 10	9500	-	2	-		Two Flights 2	
N 17	2000	3	-	-	Normal 3		
N 18	3300	2	-	-	Normal 2		
N 19	7900	3	-	-	Expendable 3		
N 20	1500	4	-	-	Kick Stage 4		
N 22	4000	4	-	-	Expendable 4		
N 23	6600	2	-	-	Expendable 2		
N 24	4400	4	-	-	Expendable 4		
D 12b	2400	-	-	5			-
TOTAL	DEPLOY	22	-	-	22		
	RETRIEVE	-	25	-		25	
	SORTIE	-	-	5			-
	TOTAL	52			47		

N = NASA D = DOD

2.3 FLIGHT DATA

2.3.1 Flight-by-Flight Mission Assignments

The following table (Tables 2-6) present the flight by flight mission assignments for each of the Tug flights for each year of the program. ETR and WTR launches are shown on separate pages.

Each chart shows the following data:

Flight Number - numbering of flights which is arbitrary and has no relation flight sequence or schedule.

Orbit - Mission orbit defined by altitude and inclination. In the case of interplanetary missions the mission velocity is given.

Flight Mode - the flight mode the Tug will operate to perform the mission. Flight modes used by the Option 1 Tug are defined as follows:

A	single payload deployment
A( )	multi-payload deployment
A-KL	payload deployment using kick stage (planetary mission)
A-E	payload deployment expending the Tug (planetary mission)
AB	Round-trip (single payload deployment and single payload retrieval)
A()B	Round-trip (multi-payload deployment and single payload retrieval)
BA	Sortie mission (round-trip of one payload with mission duration equal to Tug duration capability)
I	Mission performed with initial configuration (all missions not so designated are performed with final configuration).

MISSION CAPTURE
OPTION 3S

LAUNCH SITE ETR YEAR: 1980

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	A	4	1800	–	–
2	"	A	8	3500	–	–
3	"	A	3	2100	–	–

MISSION CAPTURE
OPTION 3

LAUNCH SITE ETR YEAR 1981

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	A	B	3500	–	–
2	"	A	7	3000	–	–
3	"	A	4	1800	–	–
4	"	A	3	2100	–	–
5	"	A	3	2100	–	–
6	"	A	3	2100	–	–
7	"	A	3	2100	–	–
8	"	A	3	2100	–	–
9	"	A	3	2100	–	–
10	"	A	3	2100	–	–
11	"	A	2	1700	–	–
12	"	A	2	1700	–	–
13	6900 /55	A	10	6000	–	–
14	POLAR/29	A	11	1700	–	–
DOD FLIGHTS						
1		A	2	690	–	–
2		A	2	690	–	–
3		A	4a	3480	–	–
4		A	4a	3480	–	–
5		A	10	2745	–	–
6		A	8	2430	–	–
7		A	8	2430	–	–

MISSION CAPTURE
OPTION 3

LAUNCH SITE ETR YEAR: 1982

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	A	B	3500	-	-
2	"	A	7	3000	-	-
3	"	A	7	3000	-	-
4	"	A	6	2600	-	-
5	"	A	3	2100	-	-
6	"	A	3	2100	-	-
7	"	A	3	2100	-	-
8	"	A	1	900	-	-
9	"	A	1	900	-	-
10	1 AU	A	9	1400	-	-
11	23,000 fps	A-KL	20	900	-	-
12	"	A-KL	20	900	-	-
DOD FLIGHTS						
1		A	2	690	-	-
2		A	2	690	-	-
3		A	3b	1570	-	-
4		A	15	1970	-	-
5		A(2)	3a, 3a	3140	-	-
6		A(2)	3a, 3a	3140	-	-
7		A	4b	3480	-	-
8		A	4b	3480	-	-
9		A	8	2430	-	-
10		A	8	2430	-	-

V-3

MISSION CAPTURE
OPTION 3

LAUNCH SITE ETR YEAR 1985

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	A	8	3500	-	-
2	"	A	8	3500	-	-
3	"	A	7	3000	-	-
4	"	A	7	3000	-	-
5	"	A	5	1800	-	-
6	"	A	5	1800	-	-
7	"	A	5	1800	-	-
8	"	A	4	1800	-	-
9	"	A	4	1800	-	-
10	"	A	3	2100	-	-
11	"	A	3	2100	-	-
12	"	A	3	2100	-	-
13	"	A	2	1700	-	-
14	"	A	1	900	-	-
15	50 x 160 NM/28.5	A	11	1700	-	-
DOD FLIGHTS						
1		A	2	690	-	-
2		A	2	690	-	-
3		A	3b	1570	-	-
4		A	15	1970	-	-
5		A	17	2200	-	-
6		A	17	2200	-	-
7		A(2)	3a, 3a	3140	-	-
8		A(2)	3a, 3a	3140	-	-
9		A	4b	3480	-	-
10		A	10	2745	-	-
11		A	8	2430	-	-
12		A	8	2430	-	-
13		A(3)·KL	11a, 11a, 11a	2550	-	-

MISSION CAPTURE
OPTION 3

LAUNCH SITE WTR YEAR. 1983

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	VARIOUS	A(2)	12,13	3000	—	—
2	VARIOUS	A(2)	14,15	2800	—	—
3	500/99	A(2)	16,16	9000	—	—
4	"	A(2)	16,16	9000	—	—
DOD FLIGHTS						
1		A(3)	5,5,5	2205	—	—
2		A(2)	16,16	5220	—	—
3		A(2)	16,16	5220	—	—
4		BA	12a	6000	12a	6000

MISSION CAPTURE
OPTION 3

LAUNCH SITE ETR YEAR: 1984

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	I-A	8	3500		
2	"	I-A	8	3500		
3	"	I A	7	3000		
4	"	A	4	1800		
5	"	B	-	-	4	1800
6	"	B	-	-	4	1800
7	"	AB	3	2100	1	900
8	"	B	-	-	3	2100
9	"	B	-	-	3	2100
10	"	B	-	-	3	2100
11	"	B	-	-	2	1700
12	"	B	-	-	2	1700
13	"	B	-	-	2	1700
14	"	A(2) B	1,1	1800	1	900
15	1 AU.	I-A	9	1400	-	
16	6900 / 55	I-A	10	6000	-	-
17	13000 fps	I-A	18	2000	-	-
18	"	I-A	18	2000	-	-
19	23000 fps	I-A-KL	20	900	-	-
20	"	I-A-KL	20	900	-	-
21	22000 fps	I-A-E	24	3300	-	-
22	"	I-A-E	24	3300	-	-
DOD FLIGHTS						
1		AB	2	690	2	690
2		AB	2	690	2	690
3		AB	3b	1570	3b	1570
4		I-A	15	1970	-	-
5		B	-	-	15	1970
6		I-A	17	2200	-	-
7		I-A	17	2200	-	-
8		I-A	4a	3480	-	-
9		I-A	4a	3480	-	-
10		AB	3a	1570	3a	1570
11		AB	3a	1570	3a	1570
12		AB	3a	1570	3a	1570
13		AB	3a	1570	3a	1570
14		B	-	-	10	2745
15		AB	8	2430	8	2430
16		AB	8	2430	8	2430
17		A(3)	11b, 11b 11b	2550	-	-

MISSION CAPTURE
OPTION 3

LAUNCH SITE WTR YEAR. 1984

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	1800 x 180/90	B	–	–	12	2000
2	20K x 1K/90	B	–	–	13	1000
3	300 x 3K/90	AB	14	800	14	800
4	700/100	AB	15	2000	15	2000
DOD FLIGHTS						
1		I-A(3)	5, 5, 5	2205	–	–

MISSION CAPTURE
OPTION 3

LAUNCH SITE ETR YEAR 1985

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC, EQ	I-A	8	3500	–	–
2	"	I-A	8	3500	–	–
3	"	I-A	7	3000	–	–
4	"	I-A	7	3000	–	–
5	"	I-A	6	2600	–	–
6	"	AB	2	1700	1	900
7	"	B	–	–	3	2100
8	"	AB	1	900	2	1700
9	"	I-A	3	2100	–	–
10	"	I-A	3	2100	–	–
11	"	I-A	3	2100	–	–
12	"	I-A	3	2100	–	–
13	"	I-A	3	2100	–	–
14	"	B	–	–	3	2100
15	"	B	–	–	3	2100
16	"	B	–	–	3	2100
17	"	B	–	–	3	2100
18	"	B	–	–	3	2100
19	"	B	–	–	3	2100
20	"	I-A	4	1800	–	–
21	"	B	–	–	4	1800
22	30K x 160K/29	AB	11	1700	11	1700
DOD FLIGHTS						
1		AB	2	690	2	690
2		AB	2	690	2	690
3		A	15	1970	–	–
4		B	–	–	15	1970
5		I-A	6	3480	–	–
6		I-A	6	3480	–	–
7		AB	4b	3480	4b	3480
8		AB	4b	3480	4b	3480
9		AB	8	2430	8	2430
10		AB	8	2430	8	2430
11		A(3)	11c, 11c, 11c	2550	–	–

MISSION CAPTURE
OPTION 3

LAUNCH SITE WTR YEAR 1985

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	VARIOUS	A(3) B	12,13,14	3800	14	800
2	700/100	AB	15	2000	15	2000
3	500/99	AB	16	4500	16	4500
4	"	AB	16	4500	16	4500
5	"	AB	16	4500	16	4500
6	"	AB	16	4500	16	4500
DOD FLIGHTS						
1		A(2)	16,16	5220	—	—
2		BA	12a	6000	12a	6000

MISSION CAPTURE
OPTION 3

LAUNCH SITE ETR YEAR. 1986

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	I-A	8	3500		
2	"	I-A	8	3500		
3	"	I-A	3	2100		
4	"	I-A	3	2100		
5	"	I-A	3	2100		
6	"	I-A	3	2100		
7	"	AB	3	2100	1	900
8	"	B	-	-	3	2100
9	"	B	-	-	3	2100
10	"	B	-	-	3	2100
11	"	B	-	-	2	1700
12	"	B	-	-	2	1700
13	"	B	-	-	4	1800
14	"	AB	1	900	1	900
15	1 AU	I-A(2)	9,9	2800	-	-
16	16,500 fps	I-A-KL	19	5500	-	-
17	24000 fps	I-A-E	22	2500	-	-
18	18400 fps	I-A-KL	23	5000	-	-
19	"	I-A-KL	23	5000	-	-
20	30K×16K/29	B	-	-	11	1700
DOD FLIGHTS						
1		AB	2	690	2	690
2		AB	2	690	2	690
3		AB	3b	1570	3b	1570
4		I-A	17	2200	-	-
5		AB	3a	1570	3a	1570
6		AB	3a	1570	3a	1570
7		AB	3a	1570	3a	1570
8		AB	3a	1570	3a	1570
9		AB	4b	3480	4b	3480
10		AB	8	2430	8	2430
11		B	-	-	10	2745
12		AB	8	2430	8	2430

MISSION CAPTURE

LAUNCH SITE WTR YEAR 1986

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	180x180/90	B	–	–	12	2000
2	20Kx1K/90	B	–	–	13	1000
3	300x3000/90	AB	14	800	14	800
4	700/190	AB	15	2000	15	2000
DOD FLIGHTS						
1		I-A(3)	555	2205	–	–
2		AB	16	2610	16	2610
3		AB	16	2610	16	2610
4		B	–	–	16	2610
5		B	–	–	16	2610

MISSION CAPTURE
OPTION 3

LAUNCH SITE ETR YEAR: 1987

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	A	B	3500	—	—
2	"	A	B	3500	—	—
3	"	A	7	3000	—	—
4	"	A	7	3000	—	—
5	"	A(2)	6,2	4300	—	—
6	"	A(2)	4,4	3600	—	—
7	"	A(2)	3,3	4200	—	—
8	"	B	—	—	3	2100
9	"	B	—	—	3	2100
10	"	B	—	—	3	2100
11	"	A(2)	3,1	3000	—	—
12	"	A(2)	3,3	4200	—	—
13	"	AB	3	2100	1	900
14	6900 / 55	I-A	10	6000	—	—
15	30KX160K / 29	I-A	11	1700	—	—
16	16500 fps	I-A-KL	19	5500	—	—
17	"	I-A-KL	19	5500	—	—
18	24000 fps	I-A-E	22	2500	—	—
DOD FLIGHTS						
1		AB	2	690	2	690
2		AB	2	690	2	690
3		AB	3b	1570	3b	1570
4		A	15	1970	—	—
5		B	—	—	15	1970
6		A	6	3480	—	—
7		A	4a	3480	—	—
8		A	4a	3480	—	—
9		AB	3a	1570	3a	1570
10		AB	3a	1570	3a	1570
11		AB	3a	1570	3a	1570
12		AB	3a	1570	3a	1570
13		AB	B	2430	B	2430
14		AB	B	2430	B	2430

MISSION CAPTURE
OPTION 3

LAUNCH SITE WTR YEAR 1987

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	VARIOUS	A(3) B	12, 13, 14	3800	14	800
2	700/99	AB	15	2000	15	2000
3	500/99	B	—	—	16	4500
4	"	B	—	—	16	4500
5	"	B	—	—	16	4500
6	"	B	—	—	16	4500
DOD FLIGHTS						
1		A(3)	5, 5, 5	2205	—	—
2		BA	12a	6000	12a	6000

MISSION CAPTURE
OPTION 3

LAUNCH SITE ETR YEAR 1988

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	A	B	3500	–	–
2	"	A	B	3500	–	–
3	"	A	7	3000	–	–
4	"	AB	1	900	1	900
5	"	A(2)	1, 3	3000	–	–
6	"	A(2)	3, 4	3900	–	–
7	"	B	–	–	4	1800
8	"	B	–	–	4	1800
9	"	B	–	–	2	1700
10	"	A(2)	3, 3	4200	–	–
11	"	A(2)	3, 3	4200	–	–
12	"	A	3	2100	–	–
13	"	B	–	–	3	2100
14	1 AU	A	9	1400	–	–
15	30K x 164/29	B	–	–	11	1700
DOD FLIGHTS						
1		AB	2	690	2	690
2		AB	2	690	2	690
3		AB	3b	1570	3b	1570
4		A	15	1970	–	–
5		B	–	–	15	1970
6		A	17	2200	–	–
7		AB	3a	1570	3a	1570
8		AB	3a	1570	3a	1570
9		AB	3a	1570	3a	1570
10		AB	3a	1570	3a	1570
11		AB	4b	3480	4b	3480
12		AB	4b	3480	4b	3480
13		B	–	–	10	2745
14		AB	8	2430	8	2430
15		AB	8	2430	8	2430
16		A(3)	11a, 11a, 11a	2550	–	–

MISSION CAPTURE
OPTION 3

LAUNCH SITE WTR YEAR 1988

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	180 x 180/90	B	—	—	12	2000
2	20K x 1K/90	B	—	—	13	1000
3	300 x 300/90	AB	14	800	14	800
4	700/100	AB	15	2000	15	2000
DOD FLIGHTS						
1		AB	16	2610	16	2610
2		AB	16	2610	16	2610

MISSION CAPTURE
OPTION 3

LAUNCH SITE ETR YEAR 1989

FLIGHT NO	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	A	8	3500	—	—
2	"	A	8	3500	—	—
3	"	A	7	3000	—	—
4	"	A(2)	5,2	3500	—	—
5	"	AB	5	1800	1	900
6	"	A	5	1800	—	—
7	"	AB	1	900	4	1800
8	"	A	3	2100	—	—
9	"	A	3	2100	—	—
10	"	B	—	—	3	2100
11	"	B	—	—	3	2100
12	"	B	—	—	3	2100
13	"	B	—	—	3	2100
14	"	B	—	—	3	2100
15	30K x 16K/28	A	11	1700	—	—
16	13000 fps	A	17	1000	—	—
17	"	A	17	1000	—	—
18	24000 fps	A-E	22	2500	—	—
19	22000 fps	A-E	24	3300	—	—
20	22000 fps	A-E	24	3300	—	—
DOD FLIGHTS						
1		AB	2	690	2	690
2		AB	2	690	2	690
3		A	15	1970	—	—
4		B	—	—	15	1970
5		A	17	2220	—	—
6		B	—	—	17	2200
7		B	—	—	17	2200
8		A	6	3480	—	—
9		AB	46	3480	46	3480
10		AB	8	2430	8	2430
11		AB	8	2430	8	2430
12		A(3)	11b, 11b, 11b	2550	—	—

MISSION CAPTURE
OPTION 3

LAUNCH SITE WTR YEAR 1989

FLIGHT NO	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	VARIOUS	A(3) B	12, 13, 14	3800	14	800
2	700/100	AB	15	2000	15	2000
3	500/99	A(2)	16, 16	9000	–	–
4	"	A(2)	16, 16	9000	–	–
5	"	A(2)	16, 16	9000	–	–
DOD FLIGHTS						
1		A(3)	5, 5, 5	2205	–	–
2		AB	16	2610	16	2610
3		AB	16	2610	16	2610
4		BA	12a	6000	12a	6000

MISSION CAPTURE
OPTION 3

LAUNCH SITE ETR YEAR 1990

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	A	B	3500	—	—
2	"	A	B	3500	—	—
3	"	A	6	2600	—	—
4	"	A	6	2600	—	—
5	"	AB	1	900	4	1800
6	"	AB	1	900	2	1700
7	"	AB	3	2100	1	900
8	"	AB	3	2100	1	900
9	"	A	3	2100	—	—
10	"	B	—	—	3	2100
11	"	B	—	—	3	2100
12	"	B	—	—	3	2100
13	"	B	—	—	3	2100
14	"	B	—	—	3	2100
15	1 AU	A(2)	9,9	2800	—	—
16	6900/55	A	10	6000	—	—
17	30K×16K/29	B	—	—	11	1700
18	24000 fps	A-E	22	2500	—	—
DOD FLIGHTS						
1		AB	2	690	2	690
2		AB	2	690	2	690
3		AB	3b	1570	3b	1570
4		A	15	1970	—	—
5		B	—	—	15	1970
6		A	17	2200	—	—
7		B	—	—	17	2200
8		B	—	—	17	2200
9		A	4a	3480	—	—
10		A	4a	3480	—	—
11		AB	3a	1570	3a	1570
12		AB	3a	1570	3a	1570
13		AB	3a	1570	3a	1570
14		AB	3a	1570	3a	1570
15		AB	B	2430	B	2430
16		AB	B	2430	B	2430
17		A(3)	11c, 11c, 11c	2550	—	—

MISSION CAPTURE
OPTION 3

LAUNCH SITE: WTR YEAR: 1990

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	1800x180/90	B	—	—	12	2000
2	20 Kx1K/90	B	—	—	13	1000
3	300x3K/90	AB	14	800	14	800
4	700/100	AB	15	2000	15	2000
DOD FLIGHTS						
1		A(3)	5,5,5	2205	—	—

2.3.2 Mission Model

The mission model for Option 3 is provided in the following table (Table 2-7). This is the mission model provided by the Government and is repeated here for completeness. The data shown on the table includes:

1. Mission Number (and DOD identification number for DOD missions)
2. Payload Weight (in pounds)
3. Payload Length and Diameter (in feet)
4. Number of mission per year (1980 through 1990) for both up payload and down payload traffic.
5. Total traffic for each payload
6. Subtotal yearly traffic for NASA and DOD
7. Total yearly traffic

MISSION MODEL OPTION 3

		WEIGHT L / D	80	81	82	83	84	85	86	87	88	89	90	TOTALS
1		900 / 10 / 6	2	2	2	1	2 / 2	1 / 1	1 / 2	1 / 1	2 / 1	1 / 1	2 / 2	17 / 10
2		1700 / 8 / 8	1	2		1	3	1 / 1	2	1	1	1	1	7 / 8
3		2100 / 12 / 8	3	7	3	3	1 / 3	5 / 7	5 / 3	6 / 3	7 / 1	2 / 5	3 / 5	45 / 27
4		1800 / 10 / 14	1	1		2	1 / 2	1 / 1	1	2	1 / 2	1	1	9 / 8
5		1800 / 17 / 10				3						3		6 / 0
6		2600 / 12 / 8	1		1			1		1			2	6 / 0
7		3000 / 20 / 10	1	1	2	2	1	2		2	1	1		13 / 0
8		3500 / 25 / 14	2	1	1	2	2	2	2	2	2	2	2	20 / 0
9		1400 / 9 / 6	1		1		1		2		1		2	8 / 0
10		6000 / 12 / 8		1			1			1			1	4 / 0
11		1700 / 8 / 8	1	1		1		1 / 1	1	1	1	1	1	6 / 4
12		2000 / 8 / 6				1	1	1	1	1	1	1	1	4 / 4
13		1000 / 7 / 7				1	1	1	1	1	1	1	1	4 / 4
14		800 / 10 / 5				1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	8 / 7
15		2000				1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	8 / 7
16		4500 / 11 / 13				4		4 / 4		4		6		14 / 8

MISSION MODEL OPTION 3 (CONT.)

		WEIGHT L / D	80	81	82	83	84	85	86	87	88	89	90	TOTALS
17		1000 / 12 | 10	1									2		3
18		2000 / 12 | 10					2							2
19		5500 / 20 | 12							1	2				3
20		900 / 17 | 10			2		2							4
21		1600 / 15 | 10												0
22		2500 / 16 | 12							1	1		1	1	4
23		5000 / 17 | 12							2					2
24		3300 / 17 | 12					2					2		4
SUB-TOTAL	NASA		14 / 0	16 / 0	12 / 0	23 / 0	17 / 14	22 / 17	16 / 13	24 / 10	16 / 10	26 / 9	15 / 14	201 / 87

MISSION MODEL OPTION 3 (CONT.)

		WEIGHT L / D	80	81	82	83	84	85	86	87	88	89	90	TOTALS
25	2	690 / 12 / 5	2 /	2 /	2 /	2 /	2 / 2	2 / 2	2 / 2	2 / 2	2 / 2	2 / 2	2 / 2	22 / 14
26	3b	1570 / 15 / 5	1 /	/	1 /	1 /	1 / 1	/	1 / 1	1 / 1	1 / 1	/	1 / 1	8 / 5
27	15	1970 / 16 / 10	1 /	/	1 /	1 /	1 / 1	1 / 1	/	1 / 1	1 / 1	1 / 1	1 / 1	9 / 6
28	17	2200 / 12 / 10	/	/	/	2 /	2 /	/	1 /	/	1 /	1 / 2	1 / 2	8 / 4
29	12b	2400 / 20 / 10	/	/	/	/	/	/	/	/	/	/	/	0 / 0
30	6	3480 / 20 / 9	/	/	/	/	/	2 /	/	1 /	/	1 /	/	4 / 0
31	4a	3480 / 25 / 15	/	2 /	/	/	2 /	/	/	2 /	/	/	2 /	8 / 0
32	3a	1570 / 15 / 5	4 /	/	4 /	4 /	4 / 4	/	4 / 4	4 / 4	4 / 4	/	4 / 4	32 / 20
33	4b	3480 / 25 / 15	1 /	/	2 /	1 /	/	2 / 2	1 / 1	/	2 / 2	1 / 1	/	10 / 6
34	10	2745 / 20 / 9	/	1 /	/	1 /	1 /	/	1 /	/	/ 1	/	/	2 / 3
35	8	2430 / 25 / 12.7	2 /	2 /	2 /	2 /	2 / 2	2 / 2	2 / 2	2 / 2	2 / 2	2 / 2	2 / 2	22 / 14
36	11a	850 / 9 / 6	3 /	/	/	3 /	/	/	/	/	3 /	/	/	9 / 0
37	11b	850 / 9 / 6	3 /	/	/	/	3 /	/	/	/	/	3 /	/	9 / 0
38	11c	850 / 9 / 6	3 /	/	/	/	/	3 /	/	/	/	/	3 /	9 / 0
39	5	735 / 3 / 5	/	/	/	3 /	3 /	/	3 /	3 /	/	3 /	3 /	18 / 0
40	16	2610 / 14.5 / 6.7	/	/	/	4 /	/	2 /	2 / 4	/	2 / 2	2 / 2	/	12 / 8
41	12a	6000 / 20 / 10	/	/	/	1 / 1	/	1 / 1	/	1 / 1	/	1 / 1	/	4 / 4
SUB. TOTAL	DOD		20 / 0	7 / 0	12 / 0	25 / 1	20 / 11	15 / 8	16 / 15	17 / 11	18 / 15	17 / 11	19 / 12	185 / 84
TOTAL			34 / 0	23 / 0	24 / 0	48 / 1	37 / 25	37 / 25	32 / 28	41 / 21	34 / 25	43 / 20	34 / 26	387 / 171

2.4 PROGRAMMATICS INPUT DATA

The following data was provided as a basic input to the programmatics studies. The first chart summarizes the total flights and hardware requirements. The second group of tables show the flight schedules and hardware requirements as a function of year. There are five tables in the group, an overall summary, NASA ETR, NASA WTR, DOD ETR and DOD WTR. These charts represent the data requested in NASA letter PD-TUG-P(028-74). The next chart shows the same flight requirements data in the format used by MDAC in the study. The final chart shows the usage of individual Tugs to accomplish the mission model. At the top of the chart, the number of flights per year is shown and the number of Tug expendable flights. The number of Tugs required were established by first determining the number of Tugs necessary to accomplish the 1990 requirements and working backward from that point.

CONFIGURATION OPTION 3

	REQUIRED	ACCOMPLISHED
DEPLOYMENTS	387	354
RETRIEVALS	171	171
FLIGHT REQUIREMENTS (NASA/DOD)	INITIAL	FINAL
# ETR LAUNCHES	82/38	97/91
# WTR LAUNCH	4/6	33/15
# REFLIGHTS DUE TO LOSSES	1	3
FLIGHT COMPOSITION		
EXPENDABLES (E)	4	4
TUG WITH BURNER II (KS_1)	-	-
TUG WITH POLARIS (KS_2)	9	-
TUG (BASIC)	117	232
VEHICLE LOSSES/REFLIGHTS	1	3
	(131)	(239)
FLEET SIZE REQUIREMENTS		
FOR OPERATIONS	4	8
FOR RELIABILITY	1	3
TOTAL	5	11
REQUIREMENT AT IOC (MIN)	2	3
FLIGHTS PER ARTICLE	33.0	30.0

I 29.7

TURNAROUND CYCLE 32.3 DAYS LAUNCH TO LAUNCH (CALENDAR DAYS)

F L I G H T S C H E D U L E

TUG CONCEPT OPTION 3

LAUNCH SITE ETR/WTR AGENCY NASA/DOD

COMPANY MDAC

	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
TUG (BASIC) **		3	21	23	36	44	40	41	40	38	41	41	370
AUXILIARY STAGE				(2)	(1)	(2)		(3)	(2)				(10)
DROP TANKS													
(OTHER)	1*												
SHUTTLE	1*	3	21	23	36	44	40	41	40	38	41	41	370

() DENOTES NUMBER EXPENDED.

REMARKS: 33 payloads not accommodated due to Shuttle limits of 3 Tug flights in 1980 and 21 in 1981

* IVU test flight

** Includes reflights due to Tug reliability losses

F L I G H T S C H E D U L E

TUG CONCEPT OPTION 3

LAUNCH SITE ETR AGENCY NASA

COMPANY MDAC

	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
TUG (BASIC)		3	14	12	15	22	22	20	18	15	20	18	179
AUXILIARY STAGE				(2)		(2)		(3)	(2)				9
DROP TANKS													0
(OTHER)	1*												1
SHUTTLE	1*	3	14	12	15	22	22	20	18	15	20	18	179

() DENOTES NUMBER EXPENDED.

REMARKS: 13 NASA payloads not accomplished due to Shuttle limit on Tug flights

* IVU test flight

F L I G H T S C H E D U L E

TUG CONCEPT OPTION 3

LAUNCH SITE ETR AGENCY DOD

COMPANY MDAC

	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
TUG (BASIC)			7	10	13	17	11	12	14	16	12	17	129
AUXILIARY STAGE					(1)								(1)
DROP TANKS													0
(OTHER)													0
SHUTTLE			7	10	13	17	11	12	14	16	12	17	129

() DENOTES NUMBER EXPENDED.

REMARKS: 20 DOD payloads not accomplished due to Shuttle limit on Tug flights

F L I G H T S C H E D U L E

TUG CONCEPT OPTION 3

LAUNCH SITE WTR AGENCY NASA

COMPANY MDAC

	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
TUG (BASIC)					4	4	6	4	6	4	5	4	37
AUXILIARY STAGE													0
DROP TANKS													0
(OTHER)													0
SHUTTLE					4	4	6	4	6	4	5	4	37

() DENOTES NUMBER EXPENDED.

REMARKS:

F L I G H T S C H E D U L E

TUG CONCEPT OPTION 3

LAUNCH SITE WTR AGENCY DOD

COMPANY MDAC

	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
TUG (BASIC)					4	1	2	5	2	2	4	1	21
AUXILIARY STAGE													0
DROP TANKS													0
(OTHER)													0
SHUTTLE					4	1	2	5	2	2	4	1	21

() DENOTES NUMBER EXPENDED.

REMARKS:

FLIGHT REQUIREMENTS

OPTION 3

	80	81	82	83	84	85	86	87	88	89	90	TOTAL
ETR												
NASA	3	14	10	15	18	22	16	15	15	17	17	162
DOD	-	7	10	12	17	11	12	14	16	12	17	128
NASA EXPENDABLE	-	-	-	-	2	-	1	1	-	3	1	8
NASA KICK STAGE	-	-	2	-	2	-	3	2	-	-	-	9
DOD KICK STAGE	-	-	-	1	-	-	-	-	-	-	-	1
TOTAL	3	21	22	28	39	33	32	32	31	32	35	308
WTR												
NASA	-	-	-	4	4	6	4	6	4	5	4	37
DOD	-	-	-	4	1	2	5	2	2	4	1	21
TOTAL	0	0	0	8	5	8	9	8	6	9	5	58
REFLIGHTS / LOSSES			1		1				1		1	

EQUAL USAGE SCHEDULE

OPTION 3

	80	81	82	83	84	85	86	87	88	89	90	TOTAL
NUMBER OF FLIGHTS	3	21	22	36	44	41	41	40	37	41	40	366
NUMBER OF EXPENDED TUGS					2		1			3	1	8
TUG ID 1	2	9	7	10	4							32
2	1	8	9	10	4							32
3		4	2	10	5	7	5					33
4			4	6	4	6	8	5				33
5					9	8	6	4	4	2		33
6					9	8	6	4	4	2		33
7					9	8	6	4	4	2		33
8						4	6	10	2	5	6	33
9							4	10	3	10	6	33
10								3	10	10	10	33
11									10	5	9	24
12										5	9	14
REFLIGHTS / LOSSES												

2.5 SENSITIVITY STUDY DATA

2.5.1 Two Year IOC Delay

The delay of the IOC two years (Initial to December 1981 and Final to December 1985) impacts the capture analysis in the number of flights, the number of missions accomplished and the fleet size.

The number of flights is reduced by 43 to a total of 323. The years 1980 and 1981, 1984 and 1985 are affected. The number of missions accomplished is significantly impacted. Shown below are the number of missions not accomplished for the years shown.

	MISSIONS MISSED	
	OPTION 3	TWO YEAR IOC DELAY
1980	30	34
1981	2	23
1984	0	25
1985	0	25
TOTAL	32	109

The fleet size is affected since the initial configuration must operate through 1985 without assistance from the final configuration. Since two tugs are expended in 1984 and three tugs are required in 1985 to perform the deployment missions, the initial tug fleet size must be increased by 1 (see the following chart). The total fleet size, however, remains the same since the total number of expanded tugs is the same. This means the final tug fleet size can be reduced by one. Another changed requirement is the kick stage requirement since the performance of DOD mission 11, within the tug duration capability, requires one kick stage in 1984 and one in 1985.

EQUAL USAGE SCHEDULE

OPTION 3 (TWO YEAR IOC DELAY)

	80	81	82	83	84	85	86	87	88	89	90	TOTAL
NUMBER OF FLIGHTS			22	36	33	33	41	40	37	41	40	323
NUMBER OF EXPENDED TUGS					(2)		(1)	(1)		(3)	(1)	
TUG ID 1			9	10	4							23
2			9	10	4							23
3			4	6	6	11	6					33
4				6	10	11	6	2				35
5				4	9	11	4	6	2	2		40
6							10	10	8	5		33
7							10	10	8	5		33
8							5	8	10	4	6	33
9								4	3	10	8	25
10									4	6	8	18
11									2	6	10	18
12										3	8	11
REFLIGHTS / LOSSES				1			1		1		1	4

MCDONNELL DOUGLAS

SPACE TUG SYSTEMS STUDY (CRYOGENIC)
SEPTEMBER DATA DUMP

VOLUME 4 Mission Accomplishment
Supplement 3S
Improved Option 3 Performance

SEPTEMBER 1973

PREPARED BY: SPACE TUG STUDY TEAM

APPROVED BY L. Q. Westmoreland

L. Q. WESTMORELAND
STUDY MANAGER

PREPARED FOR NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MARSHALL SPACE FLIGHT CENTER
UNDER CONTRACT NO. NAS8-29677

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY-WEST

5301 Bolsa Avenue, Huntington Beach, CA 92647

PREFACE

This study report for the Tug Program is submitted by the McDonnell Douglas Astronautics Company (MDAC) to the Government in partial response to Contract Number NAS8-29677.

The current results of this study contract are reported in eight volumes:

Volume 1 – Summary, Program Option 1
Volume 2 – Summary, Program Option 2
Volume 3 – Summary, Program Option 3

These three summary volumes present the highlights of the comprehensive data base generated by MDAC for evaluating each of the three program options. Each volume summarizes the applicable option configuration definition, Tug performance and capabilities, orbital and ground operations, programmatic and cost considerations, and sensitivity studies. The material contained in these three volumes is further summarized in the Data Dump Overview Briefing Manual.

Volume 4 – Mission Accomplishment. (3 Books and 1 Supplement Bound Together)

This volume contains mission accomplishment analysis for each of the three program options and includes the tug system performance, mission capture, and fleet size analysis.

Volume 5 – Systems (3 Books)

This volume presents the indepth design, analysis, trade study, and sensitivity technical data for each of the configuration options and each of the Tug systems i.e., structures, thermal, avionics, and propulsion. Interface with the Shuttle and Tug payloads for each of the three options is defined.

Volume 6 – Operations (3 Books)

This volume presents the results of orbital and ground operations trades and optimization studies for each option in the form of operations descriptions, time lines, support requirements (GSE, manpower, networks, etc.), and resultant costs.

Volume 7 – Safety (3 Books)

This volume contains safety information and data for the Tug Program. Specific safety design criteria applicable to each option are determined and potential safety hazards common to all options are identified.

Volume 8 – Programmatics and Cost (3 Books)

This volume contains summary material on Tug Program manufacture, facilities, vehicle test, schedules, cost, project management SR&T, and risk assessment for each option studied.

These volumes contain the data required for the three options which were selected by the Government for this part of the study and are defined as:

A. Option 1 is a direct development program (I.O.C.: Dec 1979). It emphasizes low DDT&E cost; the deployment requirement is 3500 pounds into geosynchronous orbit, it does not have retrieval capability, and it is designed for a 36-hour mission. MDAC has also prepared data for an alternative to Option 1 which deviates from certain requirements to achieve the lowest practicable DDT&E cost.

B. Option 2 is also a direct development program (I.O.C.: 1983). It emphasizes total program cost effectiveness in addition to low DDT&E cost. The deployment requirement is 3500 pounds minimum into geosynchronous orbit and 3500 pounds minimum retrieval from geosynchronous orbit.

C. Option 3 is a phased development program (I.O.C.: 1979 phased to I.O.C. 1983). It emphasizes minimum initial DDT&E cost and low total program cost. The initial Tug capability will deploy a minimum of

3500 pounds into geosynchronous orbit without retrieval capability, however, through phased development, it will acquire the added capability to retrieve 2200 pounds from geosynchronous orbit. The impact of increasing the retrieval capability to 3500 pounds is also provided.

CONTENTS

Section 1

PERFORMANCE

1.1 PERFORMANCE GROUND RULES

The payload performance was determined using the classical impulsive velocity equation. The velocities employed were based on the three dimensional finite burning trajectory analyses performed during Task 1. Since most of the missions in the mission model did not exceed three days duration, this figure was used for establishing performance capability even though subsystems are sized for six days. A detailed simulation of the basic geosynchronous deployment mission taking into account the actual losses associated with each engine start and the velocity contributed by propellant settling forces was used to determine an equivalent specific impulse penalty of four seconds which was then used for all missions.

For the geosynchronous transfer, a velocity of 13,972 fps was used which represents the most unfavorable situation (from a performance point of view) of no low orbit phasing being required and the resulting injection to the transfer orbit being performed with only one burn instead of two. This velocity is approximately 80 fps greater than the most favorable two burn transfer injection. For the return, a velocity of 13,920 fps was used.

The following weights and engine data were also employed in the performance computations:

Shuttle Capability	65,000
Ancillary equipment (to install Tug in the Orbiter bay)	2,066
Vented during ascent	269
Tug gross weight at deployment from Orbiter bay	62,665
Tug burnout weight (includes FPR)	6,840
Propellant capacity (@5.5 EMR)	55,500
Engine chilldown and propellant settling (each start)	20
Vented in flight	78
Attitude control propellant	95
Fuel Cell Reactants	83
Engine	Category II RL10
Thrust	15,000
I_{sp} (@6.0:1 EMR)	459.2

1.2 GEOSYNCHRONOUS PERFORMANCE

Based on the foregoing ground rules and data, the following geosynchronous orbit performance capabilities were determined at the nominal 5.5:1 EMR:

Deployment	6,840
Retrieval	4,354
Round Trip	2,660

For mission of greater (or less) than three days, the increase (or decrease) in on-orbit consumables must be corrected for using the factors given in Section 1.4.2. Figure 1.2-1 shows how the payload delivery capability decreases as payload is returned.

1.3 PERFORMANCE ENVELOPE

Figures 1.3-1, -2, and -3 present the payload-velocity envelope for the Option 3B Tug starting from 28.5 deg, 55 deg, and 90 deg inclinations, respectively. The significant variation with inclination reflects the Shuttle performance with launch azimuth. For missions below geosynchronous, specific impulse could be increased by off loading LOX only initially to reduce the EMR to 5.0 and gain up to three seconds.

1.4 PERFORMANCE SENSITIVITIES

1.4.1 General Mission Trade Factors

The sensitivity of payload to the two principal performance factors, —Tug inert weight and I_{sp} — are presented as a function of mission velocity in Figure 1.4-1.

1.4.2 Geosynchronous Trade Factors

Specific trade factors for the geosynchronous missions are given in Table 1.4-1. The inert weight factor is applicable to any weight carried throughout the mission, such as structure and residual propellants. The gross weight factor can correct for variations in the Tug gross weight at first ignition such as Shuttle capability, ancillary equipment or propellants vented during ascent.

1.5 MISSION PERFORMANCE

The performance capability for each mission in the mission model was computed for each basic mission mode. The missions are defined in Table 1.5-1. Table 1.5-2 is a computer printout of the results and includes the velocities

DOUGLAS

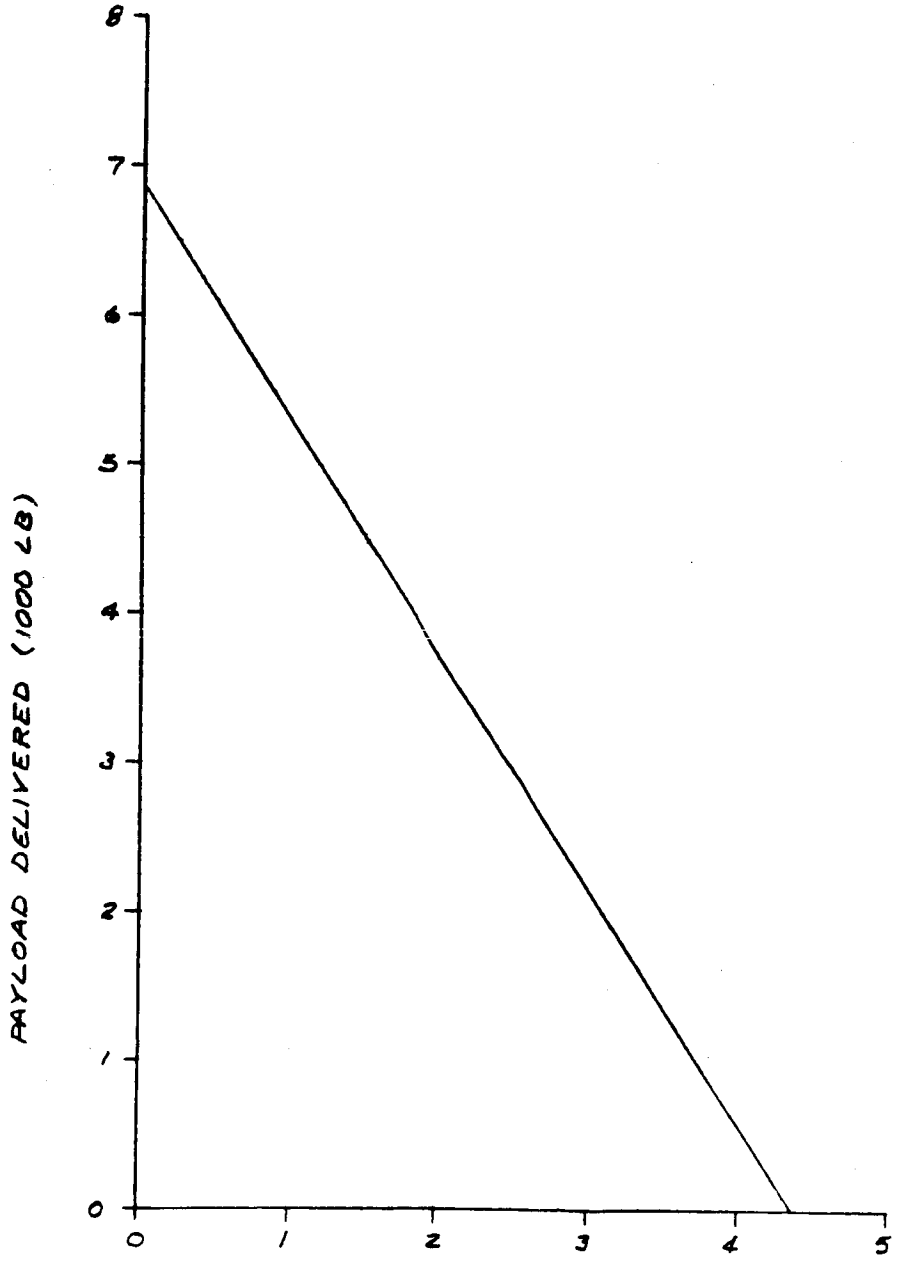
IV 4

PREPARED BY: S.P.T. MODEL REPORT NO. REVISED

REFERENCE PAGE NO. DATE

GEOSYNCHRONOUS PERFORMANCE

CONFIGURATION OPTION 3S



FORM 28-BP-4G (REV. 6-71)

PERFORMANCE CAPABILITY

CONFIGURATION OPT 3S

W_{BO} 6840

I_{SP} 462.2

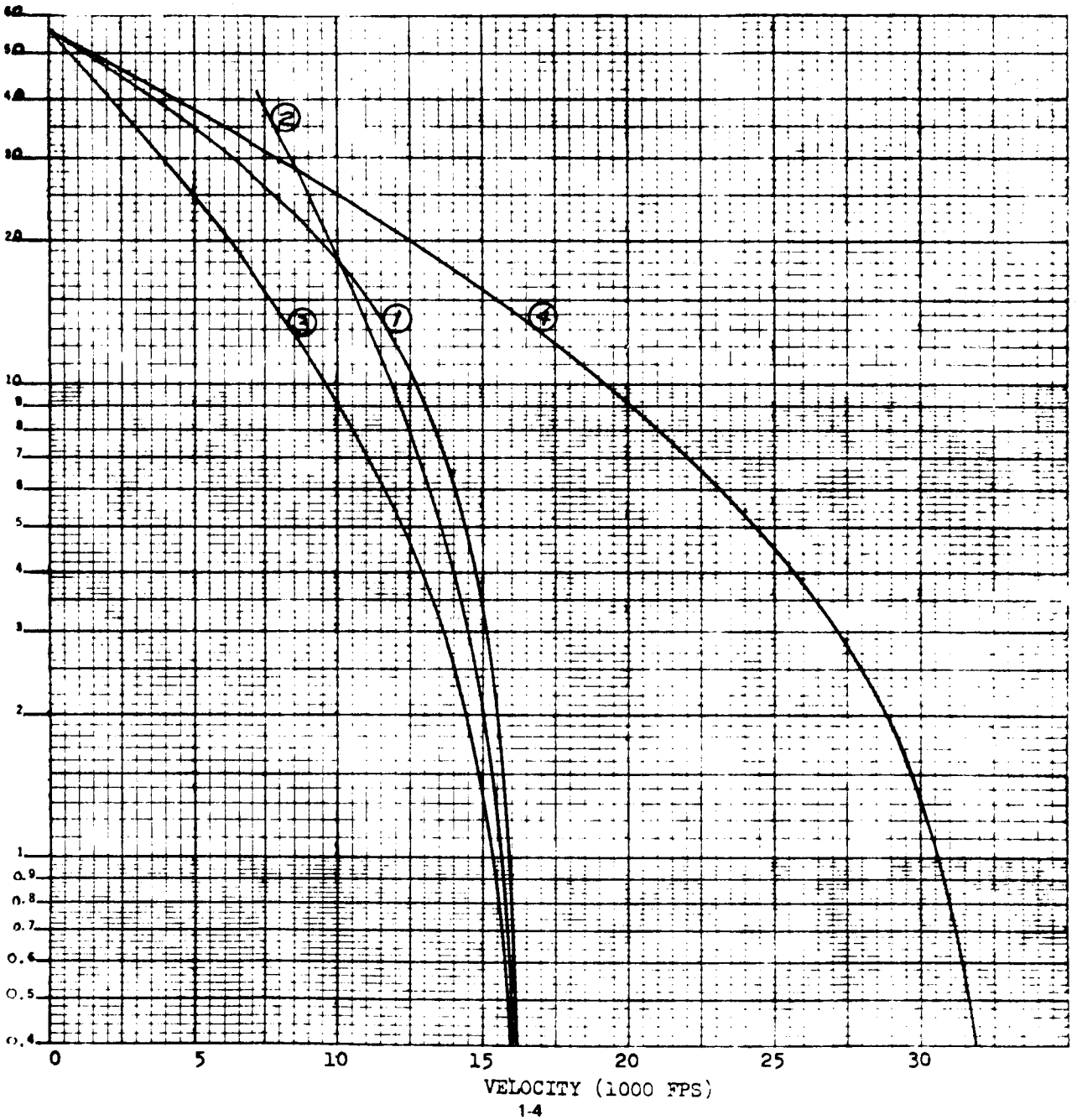
INCL 28.5°

① DEPLOY

② RETRIEVE

③ ROUND TRIP

④ EXPENDABLE



PERFORMANCE CAPABILITY

CONFIGURATION OPT 3S

W_{BO} 6840

I_{SP} 462.2

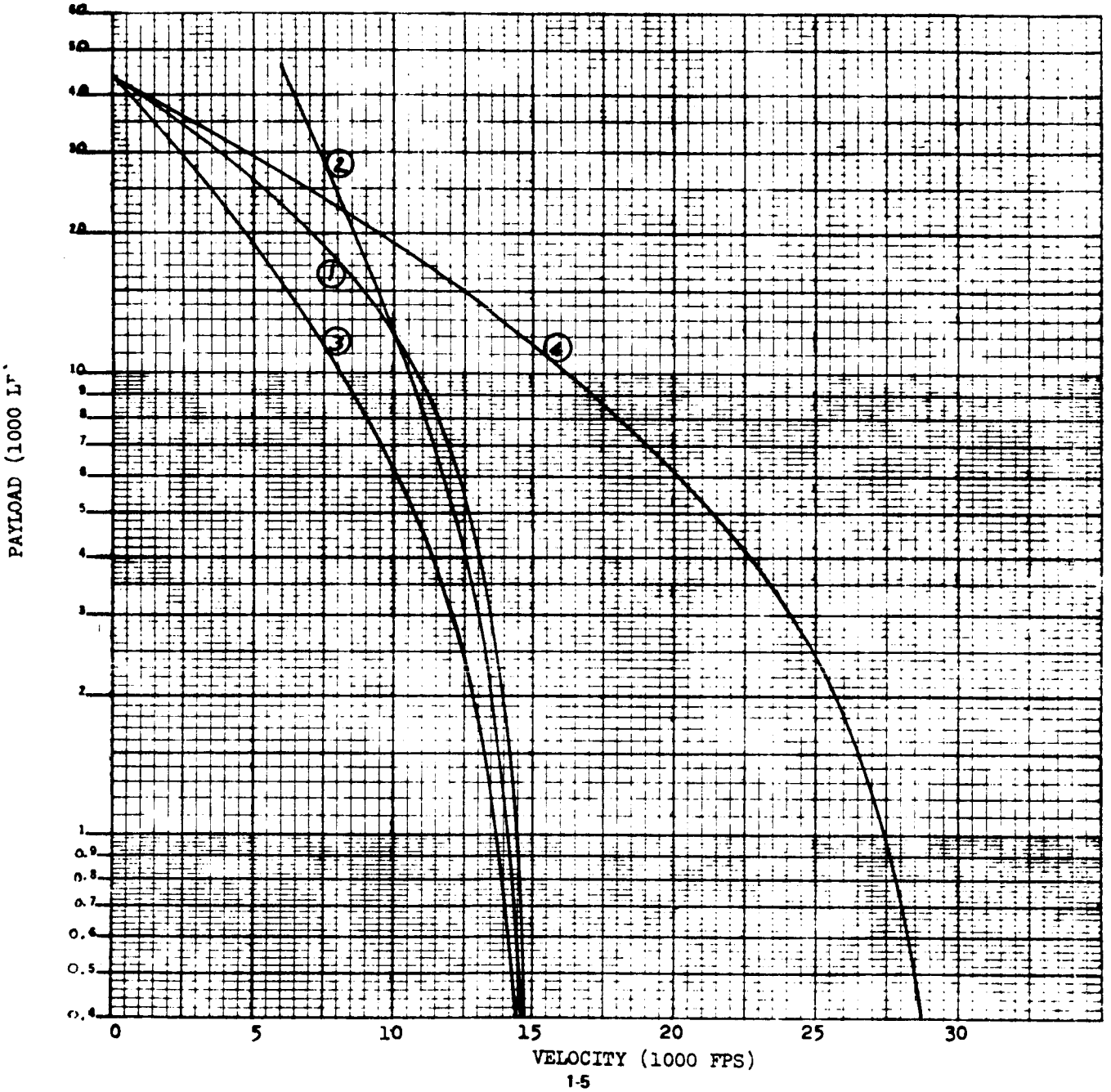
INCL 55°

① DEPLOY

② RETRIEVE

③ ROUND TRIP

④ EXPENDABLE



PERFORMANCE CAPABILITY

CONFIGURATION OPT 3S

W_{BO} 6840

I_{SP} 462.2

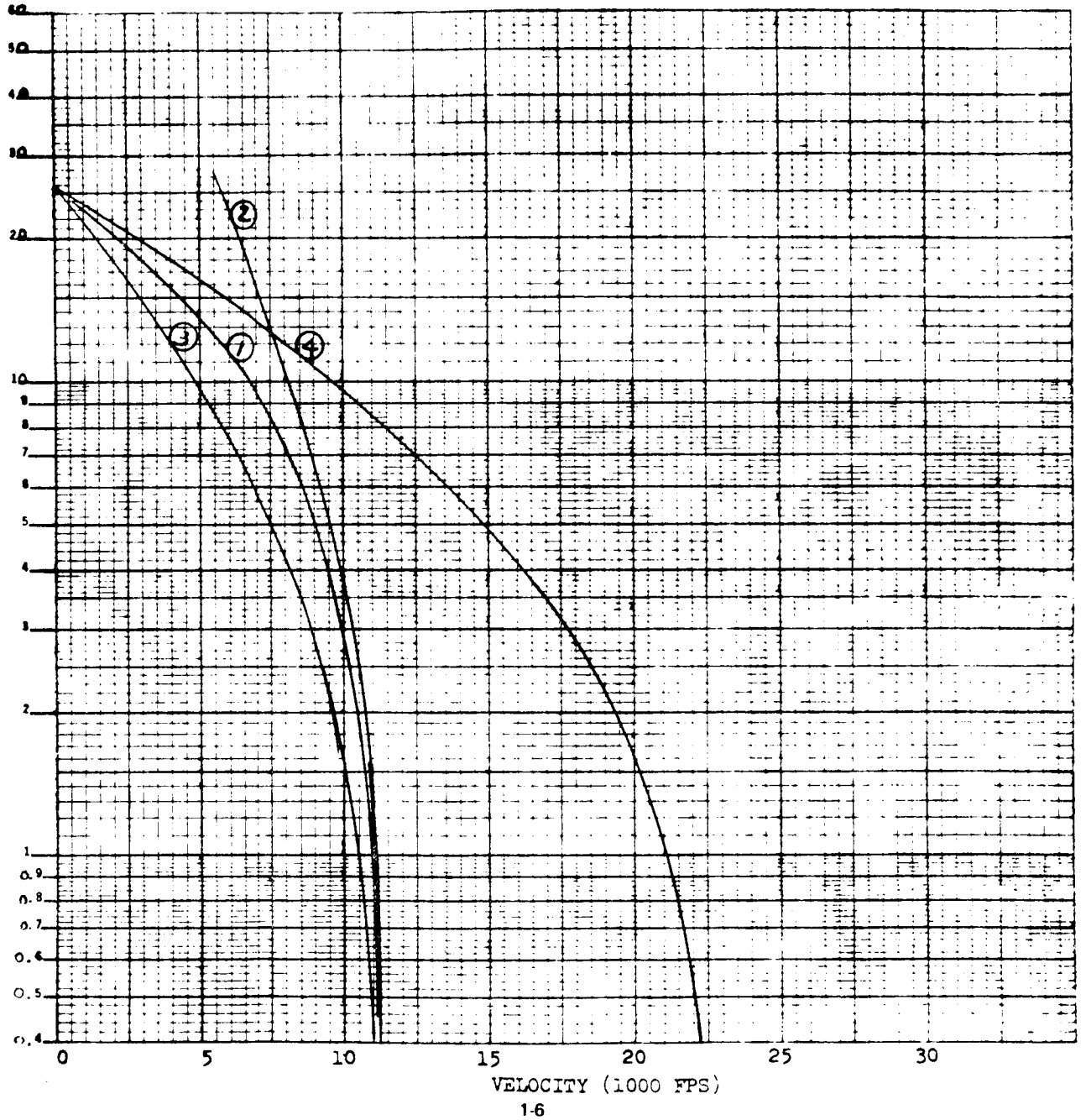
INCL 30°

① DEPLOY

② RETRIEVE

③ ROUND TRIP

④ EXPENDABLE

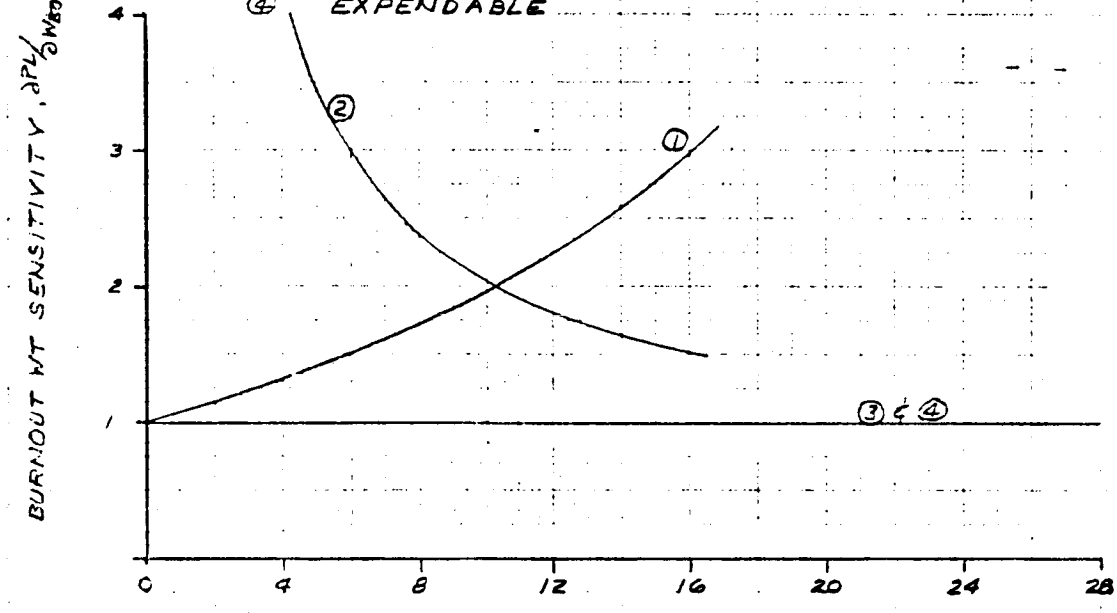


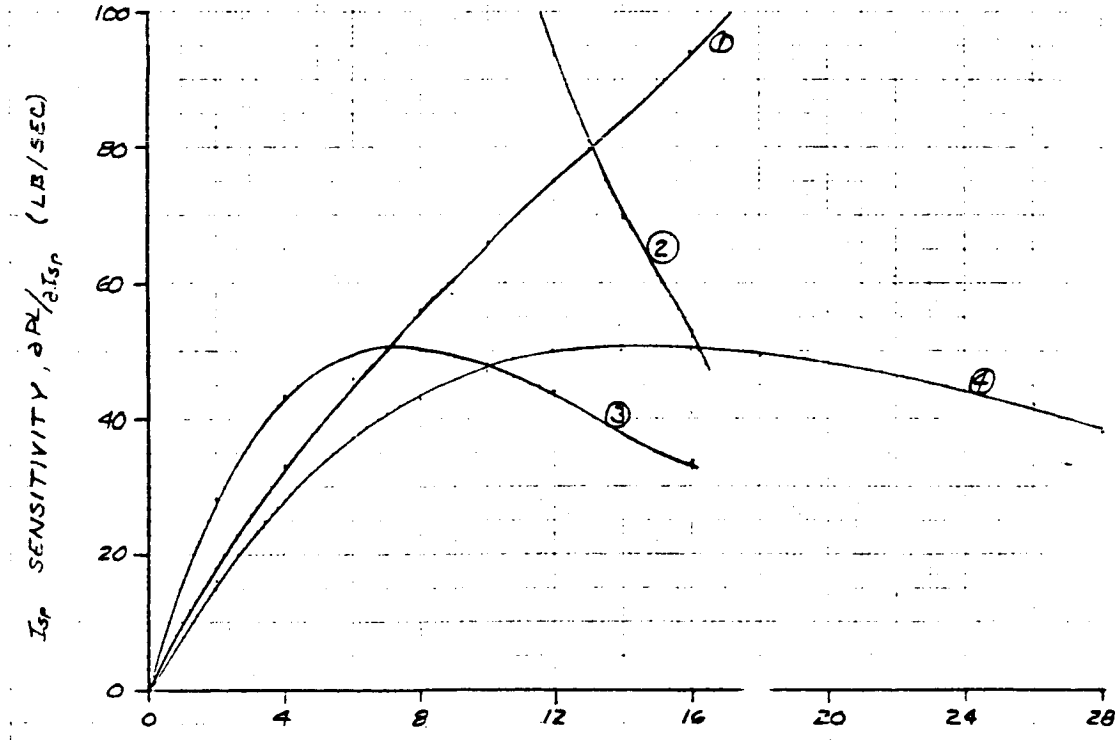
DOUGLAS

PERFORMANCE SENSITIVITY

CONFIGURATION OPTION 3S

① DEPLOY
② RETRIEVE
③ ROUND TRIP
④ EXPENDABLE





REPORT NO. _____ REVISED _____
PAGE NO. _____ DATE _____
PREPARED BY: _____ MODEL _____
REFERENCE _____

FORM 28-EP-4G (REV. 8-71)

Table 1.4-1

GEOSYNCHRONOUS MISSION TRADE FACTORS

	DEPLOY	RETRIEVE	ROUND TRIP
Burnout Weight: $\partial PL / \partial W_{BO}$	-2.57	-1.64	-1
Specific Impulse: $\partial PL / \partial I_{sp}$	84	70	38
Gross Weight: $\partial PL / \partial W_o$	.39	.25	.15
Orbit Losses: $\partial PL / \partial W_{OL}$	-1	-.64	-.39

Table 1.5-1

MISSION DESCRIPTIONS

Mission No.	$H_a \times H_p$ (nmi)	Incl.	Remarks
1-8	19323	0	Synchronous orbit - single burn transfer orbit injection
1-8A	19323	0	Synchronous orbit - two burn transfer injection
1-8B	19323	0	Synchronous orbit - two burn transfer injection with 600 fps for multiple payload deployments
9	1AU	Eclip.	
10	6900	55°	
10A	6900	55°	Alternate - Shuttle launched into 28.5°
11	16Kx30K	20°	
12	180x1800	90°	
13	1Kx20K	90°	
13A	1Kx20K	90°	ETR Alternate - Shuttle launched into 28.5°
13B	1Kx20K	90°	ETR Alternate - Shuttle launched into 55°
14	300x3000	90°	
15	700	100°	
16	500	99.2°	
17-8	Interplanetary		ΔV - 13000
19			16500
20			23000
21-2			24000
23			18400
24			22000
D11	58K	0,30,60	
D10	860x21K	63.4	Shuttle launch into 63.4° WTR
D10A	860x21K	63.4	ETR Alternate - Shuttle launched into 55°
D5	750	99°	
D3	13.6Kx25K	60°	Shuttle launched into 60° WTR
D3A	13.6x25K	60°	ETR Alternate - Shuttle launched into 55°
D12	300	104°	
D16	400	98.3°	

CØNFIGURATIØN ØPT 3S STAGE WT=6840.00 ISP=462.20 DELISP=4.00

MISSIØN	GRØSS-WT V-ØUT	PL-RØUND V-BACK	PL-DEPLØY	PL-RETRIEVE	PL-EXPEND
1-8	62665.00 13972.00	2608.05 13920.00	6704.89	4268.34	17449.45
1-8A	62665.00 13890.00	2660.75 13920.00	6840.37	4354.59	17584.93
1-8B	62665.00 14190.00	2281.84 14220.00	5986.85	3687.18	17092.91
9	62665.00 14160.00	2220.16 14350.00	5876.64	3568.23	17141.66
10	50665.00 9700.00	6749.23 9700.00	13032.00	13999.58	19399.26
10A	62665.00 12760.00	4257.38 12760.00	10116.85	7350.73	19530.77
11	62665.00 12450.00	4734.06 12450.00	11015.48	8301.93	20091.18
12	32665.00 2285.00	17118.16 2285.00	19988.11	119221.62	21134.87
13	32665.00 8400.00	3611.15 8400.00	6384.18	8313.75	11636.66
13A	62665.00 13460.00	3251.99 13460.00	8103.52	5431.81	18307.86
13B	50665.00 11200.00	4247.07 11200.00	9078.95	7980.14	16860.77
14	32665.00 3600.00	13203.56 3600.00	16855.63	60939.31	18747.55
15	26665.00 1700.00	14332.89 1700.00	16084.77	131597.75	16920.79
16	26665.00 1120.00	16066.18 1120.00	17334.34	219608.87	17874.23
17-8	62665.00 13140.00	3621.42 13250.00	8896.45	6107.61	18859.71
19	62665.00 16740.00	.00 17210.00	.00	.00	13291.43

20	62665.00 23550.00	.00 24500.00	.00	.00	5843.98
21-2	62665.00 24600.00	.00 25500.00	.00	.00	4971.98
23	62665.00 18720.00	.00 19550.00	.00	.00	10761.29
24	62665.00 22500.00	.00 23500.00	.00	.00	6780.35
D11	62665.00 13930.00	2628.59 13930.00	6762.27	4300.09	17518.75
D10	48665.00 8500.00	8520.52 8500.00	15166.02	19445.12	20500.81
D10A	50665.00 9800.00	6566.13 9800.00	12764.74	13521.58	19221.88
D5	26665.00 1770.00	14132.77 1770.00	15935.67	124918.75	16808.23
D3	48665.00 11850.00	2910.54 11850.00	6502.31	5269.06	14943.25
D3A	50665.00 11920.00	3215.31 11920.00	7217.38	5798.54	15731.05
D12	26665.00 500.00	18076.26 500.00	18699.84	542067.44	18935.80
D16	26665.00 850.00	16920.80 850.00	17925.08	302013.50	18331.05

derived from Task I. The gross weight reflects the Shuttle delivery capability to the appropriate parking orbit inclinations. In several cases, alternate mission profiles are shown starting from different inclinations. The capabilities with a kick stage were also determined for use in the mission capture analysis but are not shown simply to avoid classifying any data.

Section 2

CAPTURE ANALYSIS - OPTION 3S

2.1 FLIGHT SUMMARY

The data provided in Section 2.1.1 represents a summary of the mission captured by the Option 3S program based upon all constraints of the system potential (Tug capability) and the program schedule (Tug and related support systems availability). Section 2.1.2 identified the missions, from the Option Mission Model, which are not captured by the program and also includes the rationale for their exclusion.

2.1.1 Flight Summary Data

Tables 2-1 through 2-5 present the number of flights per year for each of the flight modes used in Option 3S. Also shown are the total Shuttle and Tug flights and the number of missions identified as requirements in the Option Mission Model. On Table 2-1 the number of missions accomplished is identified.

The mission modes used in this option are defined as follows:

Deploy

Single Payload - The deployment of one payload to one location and velocity vector and return of the Tug to the Shuttle.

Multi - 2 Payload - The deployment of two payloads to one location and velocity vector and return of the Tug to the Shuttle.

Multi - 3 Payloads - The deployment of three payloads to one location and velocity vector and return to the Shuttle.

Kick Stage - Large - The deployment of one or more payloads to one location and velocity vector using a Polaris kick stage as a second stage to the Tug. The kick stage is expended and the Tug returns to the Shuttle.

Expendable - The deployment of one payload to one location and velocity vector. The Tug is expended.

Retrieval

Single Payload - The retrieval of one payload from one location and return to the Shuttle.

Round Trip

Deploy 1/Retrieve 1 - Deploy one payload at one location and velocity vector (maneuver 60° phase angle position for synchronous equatorial mission between deployment and retrieval), retrieve one payload and return to the Shuttle.

Deploy Multi/Retrieve 1 - Deploy one payload at one location and velocity vector, maneuver to a second position and velocity vector and deploy second payload, if three satellites are to be deployed, maneuver to a third position and velocity vector and deploy third satellite and retrieve another satellite at that position (for synchronous equatorial mission each maneuver shall be 60° phase angle).

Sortie - Carry a payload to one orbital location, remain in that orbit for 130 hours (22 hours for initial configuration) and return the payload to the Shuttle.

FLIGHT SUMMARY--WTR--OPTION 3S

Flight Mode		Calendar Year											Total
		80	81	82	83	84	85	86	87	88	89	90	
Totals	Shuttle	-	-	-	8	5	8	9	8	6	9	5	58
	Tug	-	-	-	8	5	8	9	8	6	9	5	58
Tug Flight Distribution	Deploy												
	Single Payload												
	Multi--2 Payloads				6		1				3		10
	Multi--3 Payloads				1	1		1	1		1	1	6
	Kick-Stage Mode												
	Expendable												
	Retrieve												
	Single Payload					2		4	4	2		2	14
	Round Trip												
	Deploy 1/Retrieve 1					2	5	4	1	4	3	2	21
	Deploy Multi/Retrieve 1						1		1		1		3
	Sortie				1		1		1		1		4
Mission Model	Total												
	Deploy	0	0	0	16	5	11	7	8	4	16	5	72
	Retrieve	0	0	0	1	4	7	8	7	6	5	4	42

FLIGHT SUMMARY—ETR—OPTION 3S

Flight Mode		Calendar Year											Total
		80	81	82	83	84	85	86	87	88	89	90	
Totals	Shuttle	3	21	22	28	35	25	26	31	27	26	30	274
	Tug	3	21	22	28	25	25	26	31	27	26	30	274
Tug Flight Distribution	Deploy												
	Single Payload	3	21	18	25	6	3	1	8	3	6	3	97
	Multi--2 Payloads			2	2	1		1	4	4	1	1	16
	Multi--3 Payloads					1	1			1	1	1	5
	Kick-Stage Mode			2	1	2		3	2				10
	Expendable					2		1	1		3	1	8
	Retrieve												
	Single Payload					6	1	4	2	4	2	4	23
	Round Trip												
	Deploy 1/Retrieve 1					17	20	16	14	14	13	20	114
	Deploy Multi/Retrieve 1									1			1
	Sortie												
Mission Model	Total												
	Deploy	34	23	24	32	32	26	25	33	30	27	29	315
	Retrieve	0	0	0	0	23	21	20	16	19	15	24	138

FLIGHT SUMMARY—DOD—OPTION 3S

Flight Mode		Calendar Year											Total
		80	81	82	83	84	85	86	87	88	89	90	
Totals	Shuttle	-	7	10	17	18	12	17	17	17	14	18	147
	Tug	-	7	10	17	18	12	17	17	17	14	18	147
Tug Flight Distribution	Deploy												
	Single Payload		7	8	10	2	2	1	3	1	1	2	37
	Multi--2 Payloads			2	4	1	1						8
	Multi--3 Payloads				1	2	1	1	1	1	2	2	11
	Kick-Stage Mode				1								1
	Expendable												
	Retrieve												
	Single Payload					3		3	2	1	1	3	13
	Round Trip												
	Deploy 1/Retrieve 1					10	7	12	10	14	9	11	73
	Deploy Multi/Retrieve 1												
	Sortie				1		1		1		1		4
Mission Model	Total												
	Deploy	20	7	12	25	20	15	16	17	18	17	19	186
	Retrieve	0	0	0	1	13	8	15	13	15	11	14	90

FLIGHT SUMMARY—NASA—OPTION 3S

Flight Mode		Calendar Year											Total
		80	81	82	83	84	85	86	87	88	89	90	
Totals	Shuttle	3	14	12	19	22	21	18	22	16	21	17	185
	Tug	3	14	12	19	22	21	18	22	16	21	17	185
Tug Flight Distribution	Deploy												
	Single Payload	3	14	10	15	4	1		5	2	5	1	60
	Multi--2 Payloads				4			1	4	4	4	1	18
	Multi--3 Payloads												
	Kick-Stage Mode			2		2		3	2				9
	Expendable					2		1	1		3	1	8
	Retrieve												
	Single Payload					5	1	5	4	5	1	3	24
	Round Trip												
	Deploy 1/Retrieve 1					9	18	8	5	4	7	11	62
	Deploy Multi/Retrieve 1						1		1	1	1		4
	Sortie												
Mission Model	Total												
	Deploy	14	16	12	23	17	22	16	24	16	26	15	201
	Retrieve	0	0	0	0	14	20	13	10	10	9	14	90

FLIGHT SUMMARY—OPTION TOTAL—OPTION 3S

Flight Mode		Calendar Year											Total
		80	81	82	83	84	85	86	87	88	89	90	
Totals	Shuttle	3	21	22	36	40	33	35	39	33	35	35	332
	Tug	3	21	22	36	40	33	35	39	33	35	35	332
Tug Flight Distribution	Deploy												
	Single Payload	3	21	18	25	6	3	1	8	3	6	3	97
	Multi--2 Payloads			2	8	1	1	1	4	4	4	1	26
	Multi--3 Payloads				1	2	1	1	1	1	2	2	11
	Kick-Stage Mode			2	1	2		3	2				10
	Expendable					2		1	1		3	1	8
	Retrieve												
	Single Payload					8	1	8	6	6	2	6	37
	Round Trip												
	Deploy 1/Retrieve 1					19	25	20	15	18	16	22	135
	Deploy Multi/Retrieve 1						1		1	1	1		4
	Sortie				1		1		1		1		4
Mission Model	Total												
	Deploy	34	23	24	48	37	37	32	41	34	43	34	387
	Retrieve	0	0	0	1	27	28	28	23	25	20	28	180
	Total	34	23	24	49	64	65	60	64	59	63	62	567
Accomplishment	Total	4	21	24	49	64	65	60	64	59	63	62	535

2.1.2 Missions Not Captured

The availability of the Shuttle in 1980 of 3 Tug flights and in 1981 of 21 flights constrains the Tug mission assignments in these years. The following rationale was used to select payloads for each of the Tug flights in those years.

1980

1. The first flight would be a simple flight with a light payload (although large enough to warrant use of the STS). NASA Mission 4 was selected.
2. The second flight would be a simple flight with a heavy payload. NASA Mission 8 was selected.
3. The third flight would be one of the most numerous. NASA Mission 3 was selected.

1981

1. Delete missions which could be performed with current expendable launch vehicles. NASA Mission 1 (two payloads) were deleted.

The following missions were not performed in 1980:

NASA		DOD	
MISSION	NUMBER OF PAYLOADS	MISSION	NUMBER OF PAYLOADS
1	2	2	2
2	1	3b	1
3	2	15	1
6	1	3a	4
7	1	4b	1
8	1	8	2
9	1	11a	3
11	1	11b	3
17	1	11c	3

Two NASA Mission 1 payloads were not performed in 1981.

All other missions, both NASA and DOD, were performed as required.

2.2 ADDITIONAL PAYLOAD CAPTURE

The capability of the Option 3S Tug to capture missions beyond the Option 3S mission model is illustrated in Table 2-6, which indicates the mode in which the Option 3S Tug can capture various missions. The missions identified are those which are contained in the total mission model, but are excluded in the Option 3S mission model.

NASA missions 17 and 18 can be deployed in the normal Tug reusable deployment mode. NASA missions 19, 22, 23, and 24 can be performed by expending the Tug. NASA mission 20 can be accomplished in a Tug reusable mode using a kick stage (Polaris kick stage). NASA missions 6 and 7 can be retrieved in a normal retrieval mode after the orbital energy has been reduced. The reduction of the orbital energy is accomplished by using the excess capability in another mission to bring the payload part way back. The mode is called the "nudge" mode. NASA missions 8 and 10 can be retrieved in the normal retrieval mode.

DOD mission 12b can be performed by the Option 3S Tug in the normal round trip sortie mode.

OPTION 3S

ADDITIONAL PAYLOAD CAPTURE POTENTIAL

MISSIONS EXCLUDED FROM OPTION MISSION MODE					CANDIDATE CONFIGURATION 3S		
DESIGNATION		DEPLOY	RETRIEVE	SORTIE	TUG MODE		
I.D. #	WT				DEPLOY	RETRIEVE	SORTIE
N 6	5000	-	-	-		Nudge 450 fps 3	
N 7	5500	-	3	-		Nudge 750 fps 10	
N 8	4000	-	10	-		Normal 7	
N 10	9500	-	2	-		Normal 2	
N 17	2000	3	-	-	Normal 3		
N 18	3300	2	-	-	Normal 2		
N 19	7900	3	-	-	Expendable 3		
N 20	1500	4	-	-	Kick Stage 4		
N 22	4000	4	-	-	Expendable 4		
N 23	6600	2	-	-	Expendable 2		
N 24	4400	4	-	-	Expendable 4		
D 12b	2400	-	-	5			Normal 5
TOTAL	DEPLOY	22	-	-	22		
	RETRIEVE	-	22	-		22	
	SORTIE	-	-	5			5
	TOTAL	49			49		

N = NASA D = DOD

2.3 FLIGHT DATA

2.3.1 Flight-by-Flight Mission Assignments

The following table (Tables 2-6) present the flight by flight mission assignments for each of the Tug flights for each year of the program. ETR and WTR launches are shown on separate pages.

Each chart shows the following data:

Flight Number - numbering of flights which is arbitrary and has no relation flight sequence or schedule.

Orbit - Mission orbit defined by altitude and inclination. In the case of interplanetary missions the mission velocity is given.

Flight Mode - the flight mode the Tug will operate to perform the mission. Flight modes used by the Option 1 Tug are defined as follows:

A	single payload deployment
A( )	multi-payload deployment
A-KL	payload deployment using kick stage (planetary mission)
A-E	payload deployment expending the Tug (planetary mission)
AB	Round-trip (single payload deployment and single payload retrieval)
A()B	Round-trip (multi-payload deployment and single payload retrieval)
BA	Sortie mission (round-trip of one payload with mission duration equal to Tug duration capability)
I	Mission performed with initial configuration (all missions not so designated are performed with final configuration).

MISSION CAPTURE
OPTION 3S

LAUNCH SITE ETR YEAR: 1980

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	A	4	1800	-	-
2	"	A	8	3500	-	-
3	"	A	3	2100	-	-

MISSION CAPTURE
OPTION 3S

LAUNCH SITE ETR YEAR 1981

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	A	8	3500	–	–
2	"	A	7	3000	–	–
3	"	A	4	1800	–	–
4	"	A	3	2100	–	–
5	"	A	3	2100	–	–
6	"	A	3	2100	–	–
7	"	A	3	2100	–	–
8	"	A	3	2100	–	–
9	"	A	3	2100	–	–
10	"	A	3	2100	–	–
11	"	A	2	1700	–	–
12	"	A	2	1700	–	–
13	6[illegible]/55	A	10	6000	–	–
14	SOX16K/29	A	11	1700	–	–
DoD FLIGHTS						
1		A	2	670	–	–
2		A	2	670	–	–
3		A	4a	3480	–	–
4		A	4a	3480	–	–
5		A	10	2745	–	–
6		A	8	2430	–	–
7		A	8	2430	–	–

MISSION CAPTURE
OPTION 3S

LAUNCH SITE ETR YEAR: 1982

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	A	8	3500	-	-
2	"	A	7	3000	-	-
3	"	A	7	3000	-	-
4	"	A	6	2600	-	-
5	"	A	3	2100	-	-
6	"	A	3	2100	-	-
7	"	A	3	2100	-	-
8	"	A	1	900	-	-
9	"	A	1	900	-	-
10	1 A.U.	A	9	1400	-	-
11	23,000 fps	A-KL	20	900	-	-
12	"	A-KL	20	900	-	-
DOD FLIGHTS						
1		A	2	690	-	-
2		A	2	690	-	-
3		A	3b	1570	-	-
4		A	15	1970	-	-
5		A(2)	3a, 3a	3140	-	-
6		A(2)	3a, 3a	3140	-	-
7		A	4b	3480	-	-
8		A	4b	3480	-	-
9		A	8	2430	-	-
10		A	8	2430	-	-

MISSION CAPTURE
OPTION 3 S

LAUNCH SITE ETR YEAR 1983

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	A	8	3500	–	–
2	"	A	8	3500	–	–
3	"	A	7	3000	–	–
4	"	A	7	3000	–	–
5	"	A	5	1800	–	–
6	"	A	5	1800	–	–
7	"	A	5	1800	–	–
8	"	A	4	1800	–	–
9	"	A	4	1800	–	–
10	"	A	3	2100	–	–
11	"	A	3	2100	–	–
12	"	A	3	2100	–	–
13	"	A	2	1700	–	–
14	"	A	1	900	–	–
15	30K x 16K/29	A	11	1700	–	–
DOD FLIGHTS						
1		A	2	690	–	–
2		A	2	690	–	–
3		A	3b	1570	–	–
4		A	15	1970	–	–
5		A	17	2200	–	–
6		A	17	2200	–	–
7		A(2)	3a, 3a	3140	–	–
8		A(2)	3a, 3a	3140	–	–
9		A	4b	3480	–	–
10		A	10	2745	–	–
11		A	8	2430	–	–
12		A	8	2430	–	–
13		A(3)-KL	11a, 11a, 11a	2550	–	–

MISSION CAPTURE
OPTION 35

LAUNCH SITE WTR YEAR: 1983

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	VARIOUS	A(2)	12,13	3000	–	–
2	VARIOUS	A(2)	14,15	2800	–	–
3	500/99	A(2)	16,16	9000	–	–
4	"	A(2)	16,16	9000	–	–
DOD FLIGHTS						
1		A(3)	5,5,5	2205	–	–
2		A(2)	16,16	5220	–	–
3		A(2)	16,16	5220	–	–
4		BA	12a	6000	12a	6000

MISSION CAPTURE
OPTION 3S

LAUNCH SITE WTR YEAR 1984

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	180 x 180/90	B	-	-	12	2000
2	20K x 1K/90	B	-	-	13	1000
3	300 x 3K/90	AB	14	800	14	800
4	700/100	AB	15	2000	15	2000
DOD FLIGHTS						
1		I-A(3)	5,5,5	2205	-	-

MISSION CAPTURE
OPTION 3S

LAUNCH SITE: ETR YEAR: 1984

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA MISSIONS						
1	SYNC. EQ	AB	8	3500	1	900
2	"	AB	8	3500	1	900
3	"	AB	7	3000	2	1700
4	"	AB	4	1800	2	1700
5	"	AB	3	2100	2	1700
6	"	AB	1	900	4	1800
7	"	AB	1	900	4	1800
8	"	B	-	-	3	2100
9	"	B	-	-	3	2100
10	"	B	-	-	3	2100
11	22000 fps	I-A-E	24	3300	-	-
12	"	I-A-E	24	3300	-	-
13	1 AU.	I-A	9	1400	-	-
14	6900 / 55	I-A	10	6000	-	-
15	13000 fps	I-A	18	2000	-	-
16	13000 fps	I-A	18	2000	-	-
17	23000 fps	I-A-KL	20	900	-	-
18	23000 fps	I-A-KL	20	900	-	-
DOD MISSIONS						
1		AB	2	690	2	690
2		AB	2	690	2	690
3		AB	3b	1570	3b	1570
4		AB	15	1970	15	1970
5		A(2)	17,17	4400	-	-
6		I-A	4a	3480	-	-
7		I-A	4a	3480	-	-
8		B	-	-	4a	3480
9		B	-	-	4a	3480
10		AB	3a	1570	3a	1570
11		AB	3a	1570	3a	1570
12		AB	3a	1570	3a	1570
13		AB	3a	1570	3a	1570
14		B	-	-	10	2745
15		AB	8	2430	8	2430
16		AB	8	2430	8	2430
17		A(3)	11b, 11b, 11b	2550	-	-

IV.★

MISSION CAPTURE
OPTION 3S

LAUNCH SITE ETR YEAR 1985

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	I-A	8	3500		
2	"	AB	8	3500	1	900
3	"	AB	7	3000	2	1700
4	"	AB	7	3000	4	1800
5	"	AB	6	2600	3	2100
6	"	AB	4	1800	3	2100
7	"	AB	3	2100	3	2100
8	"	AB	3	2100	3	2100
9	"	AB	3	2100	3	2100
10	"	AB	3	2100	3	2100
11	"	AB	3	2100	3	2100
12	"	AB	2	1700	5	2800
13	"	AB	1	900	5	2800
14	"	B	—	—	5	2800
15	30x160K/29	AB	11	1700	11	1700
DOD FLIGHTS						
1		AB	2	690	2	690
2		AB	2	690	2	690
3		AB	15	1970	15	1970
4		I-A	6	3480	—	—
5		I-A	6	3480	—	—
6		AB	4b	3480	4b	3480
7		AB	4b	3480	4b	3480
8		AB	8	2430	8	2430
9		AB	8	2430	8	2430
10		A(3)	11c, 11c, 11c	2550	—	—

MISSION CAPTURE
OPTION 3S

LAUNCH SITE WTR YEAR: 1985

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	VARIOUS	A(3) B	12,13,14	3800	14	800
2	700 [illegible]	AB	15	2000	15	2000
3	500/[illegible]	AB	16	4500	16	4500
4	"	AB	16	4500	16	4500
5	"	AB	16	4500	16	4500
6	"	AB	16	4500	16	4500
DOD FLIGHTS						
1		A(2)	16,16	5220	—	—
2		BA	12a	6000	12a	6000

MISSION CAPTURE
OPTION 3S

LAUNCH SITE ETR YEAR 1986

FLIGHT NO	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	AB	8	3500	1	900
2	"	AB	8	3500	1	900
3	"	AB	3	2100	2	1700
4	"	AB	3	2100	2	1700
5	"	AB	3	2100	4	1800
6	"	AB	1	900	3	2100
7	"	B	—	—	3	2100
8	"	B	—	—	3	2100
9	1 A.U.	I-A(2)	9,9	2800	—	—
10	30K x 16K/29	B	—	—	11	1700
11	16500 fps	I-A-KL	19	5500	—	—
12	24000 fps	I-A-E	22	2500	—	—
13	18400 fps	I-A-KL	23	5000	—	—
14	18400 fps	I-A-KL	23	5000	—	—
DOD FLIGHTS						
1		AB	2	690	2	690
2		AB	2	690	2	690
3		AB	36	1570	36	1570
4		I-A	17	2220	—	—
5		AB	3a	1570	3a	1570
6		AB	3a	1570	3a	1570
7		AB	3a	1570	3a	1570
8		AB	3a	1570	3a	1570
9		AB	4b	3480	4b	3480
10		B	—	—	10	2745
11		AB	8	2430	8	2430
12		AB	8	2430	8	2430

MISSION CAPTURE
OPTION 3S

LAUNCH SITE WTR YEAR: 1986

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	[illegible]	B	—	—	12	2000
2	28.5x1K/90	B	—	—	13	1000
3	160x300/28.5	AB	14	800	14	800
4	160/150	AB	15	2000	15	2000
DOD FLIGHTS						
1		I-AB	555	2205	—	—
2		AB	16	2610	16	2610
3		AB	16	2610	16	2610
4		B	—	—	16	2610
5		B	—	—	16	2610

MISSION CAPTURE
OPTION 3S

LAUNCH SITE ETR YEAR 1987

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	I-A	8	3500		
2	"	AB	8	3500	1	900
3	"	I-A	7	3000	—	—
4	"	I-A	7	3000	—	—
5	"	A(2)	6,3	4700	—	—
6	"	AB	4	1800	3	2100
7	"	AB	4	1800	3	2100
8	"	AB	3	2100	3	2100
9	"	A(2)	3,3	4200	—	—
10	"	A(2)	3,3	4200	—	—
11	"	A(2)	1,2	2600	—	—
12	6900 / 55	A	10	6000	—	—
13	90K x 16K / 29	A	11	1700	—	—
14	16,500 fps	I-A-KL	19	5500	—	—
15	"	I-A-KL	19	5500	—	—
16	24000 fps	I-A-E	22	2500	—	—
DOD FLIGHTS						
1		AB	2	690	2	690
2		AB	2	690	2	690
3		AB	3b	1570	3b	1570
4		AB	15	1970	15	1970
5		A	6	3480	—	—
6		A	4a	3480	—	—
7		A	4a	3480	—	—
8		B	—	—	4a	3480
9		B	—	—	4a	3480
10		AB	3a	1570	3a	1570
11		AB	3a	1570	3a	1570
12		AB	3a	1570	3a	1570
13		AB	3a	1570	3a	1570
14		AB	8	2430	8	2430
15		AB	8	2430	8	2430

MISSION CAPTURE
OPTION 3S

LAUNCH SITE WTR YEAR 1987

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	[illegible]	A(2)B	12,13,14	3300	14	300
2	700 /28	AB	15	2000	15	2000
3	500 /98	B	—	—	16	4500
4	"	B	—	—	16	4500
5	"	B	—	—	16	4500
6	"	B	—	—	16	4500
DOD FLIGHTS						
1		A(3)	5,5,5	2205	—	—
2		BA	12a	6000	12a	6000

MISSION CAPTURE
OPTION 3S

LAUNCH SITE ETR YEAR 1988

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	A	B	3500		
2	"	AB	B	3500	1	900
3	"	AB	7	3000	4	1800
4	"	A(2)	4, 3	3900		
5	"	A(2)	3, 3	4200		
6	"	A(2)	3, 3	4200		
7	"	A(2)	3, 3	4200		
8	"	A(2)B	1, 1	1800	3	2100
9	"	B	—	—	4	1800
10	"	B	—	—	2	1700
11	1 AU	A	9	1400	—	—
12	30KX160K/28	B	—	—	11	1700
DOD FLIGHTS						
1		AB	2	690	2	690
2		AB	2	690	2	690
3		AB	3b	1570	3b	1570
4		AB	15	1970	15	1970
5		A	17	2220	—	—
6		AB	3a	1570	3a	1570
7		AB	3a	1570	3a	1570
8		AB	3a	1570	3a	1570
9		AB	3a	1570	3a	1570
10		AB	4b	3480	4b	3480
11		AB	4b	3480	4b	3480
12		B	—	—	10	2745
13		AB	8	2430	8	2430
14		AB	8	2430	8	2430
15		A(3)	11a, 11a, 11a	2550	—	—

MISSION CAPTURE
OPTION 3S

LAUNCH SITE WTR YEAR: 1988

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	180NMx180NM/28°	B	—	—	12	2000
2	20KMx1KM/90°	B	—	—	13	1000
3	300x300NM/SS	AB	14	800	14	800
4	700NM/100°	AB	15	2000	15	2000
DOD FLIGHTS						
1		AB	16	2610	16	2610
2		AB	16	2610	16	2610

MISSION CAPTURE

OPTION 3S

LAUNCH SITE ETR YEAR: 1989

FLIGHT NO	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	A	8	3500	—	—
2	"	AB	8	3500	1	900
3	"	AB	7	3000	4	1800
4	"	A(2)	5,5	5600		
5	"	A	5	2800		
6	"	AB	3	2100	3	2100
7	"	AB	3	2100	3	2100
8	"	AB	1	900	3	2100
9	"	AB	2	1700	3	2100
10	"	B	—	—	3	2100
11	30K x 16K/28.9	A	11	1700	—	—
12	13000 fps	A	17	1000	—	—
13	"	A	17	1000	—	—
14	24000 fps	A-E	22	2500	—	—
15	22000 fps	A-E	24	3300	—	—
16	"	A-E	24	3300	—	—
DOD FLIGHTS						
1		AB	2	690	2	690
2		AB	2	690	2	690
3		AB	15	1970	15	1970
4		AB	17	2220	17	2220
5		B	—	—	17	2220
6		A	6	3480	—	—
7		AB	46	3480	46	3480
8		AB	8	2430	8	2430
9		AB	8	2430	8	2430
10		A(3)	11b, 11b, 11b	2550	—	—

MISSION CAPTURE
OPTION 3S

LAUNCH SITE ETR YEAR: 1990

FLIGHT NO	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	SYNC. EQ	AB	8	3500	1	900
2	"	AB	8	3500	1	900
3	"	AB	6	2600	3	2100
4	"	AB	6	2600	3	2100
5	"	AB	3	2100	3	2100
6	"	AB	3	2100	3	2100
7	"	AB	3	2100	3	2100
8	"	AB	1	900	4	1800
9	"	AB	1	900	2	1700
10	1 AU	A(2)	9,9	2800	–	–
11	6900 / 55	A	10	6000	–	–
12	30K x 16K / 29	B	–	–	11	1700
13	24000 fps	A-E	22	2500	–	–
DOD FLIGHTS						
1		AB	2	690	2	690
2		AB	2	690	2	690
3		AB	3b	1570	3b	1570
4		AB	15	1970	15	1970
5		AB	17	2220	17	2220
6		B	–	–	17	2220
7		A	4a	3480	–	–
8		A	4a	3480	–	–
9		B	–	–	4a	3480
10		B	–	–	4a	3480
11		AB	3a	1570	3a	1570
12		AB	3a	1570	3a	1570
13		AB	3a	1570	3a	1570
14		AB	3a	1570	3a	1570
15		AB	8	2430	8	2430
16		AB	8	2430	8	2430
17		A(3)	11c, 11c, 11c	2550	–	–

MISSION CAPTURE
OPTION 3S

LAUNCH SITE WTR YEAR 1989

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA		FLIGHTS				
1	VARIOUS	A(3) B	12, 13, 14	3300	14	800
2	700/120	AB	15	2000	15	2000
3	500/99	A(2)	16, 16	9000	–	–
4	"	A(2)	16, 16	9000	–	–
5	"	A(2)	16, 16	9000	–	–
DOD		FLIGHTS				
1		A(3)	5, 5, 5	3205	–	–
2		AB	16	2610	16	2610
3		AB	16	2610	16	2610
4		BA	12a	6000	12a	6000

MISSION CAPTURE
OPTION 3 S

LAUNCH SITE WTR YEAR: 1990

FLIGHT NO.	ORBIT	FLIGHT MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT
NASA FLIGHTS						
1	[illegible]	B	—	—	12	2000
2	[illegible]	B	—	—	13	1000
3	[illegible]	AB	14	800	14	800
4	[illegible]	AB	15	2000	15	2000
DOD FLIGHTS						
1		A(3)	5,5,5	2205	—	—

2.3.2 Mission Model

The mission model for Option 3S is provided in the following table (Table 2-7). This is the mission model provided by the Government and is repeated here for completeness. The data shown on the table includes:

1. Mission Number (and DOD identification number for DOD missions)
2. Payload Weight (in pounds)
3. Payload Length and Diameter (in feet)
4. Number of mission per year (1980 through 1990) for both up payload and down payload traffic.
5. Total traffic for each payload
6. Subtotal yearly traffic for NASA and DOD
7. Total yearly traffic

MISSION MODEL OPTION 3S

		WEIGHT L / D	80	81	82	83	84	85	86	87	88	89	90	TOTALS
1		900 / 10 / 6	2	2	2	1	2 / 2	1 / 1	1 / 2	1 / 1	2 / 1	1 / 1	2 / 2	17 / 10
2		1700 / 8 / 8	1	2		1	/ 3	1 / 1	/ 2	1	/ 1	1	/ 1	7 / 8
3		2100 / 12 / 8	3	7	3	3	1 / 3	5 / 7	5 / 3	6 / 3	7 / 1	2 / 5	3 / 5	45 / 27
4		1800 / 10 / 14	1	1		2	1 / 2	1 / 1	/ 1	2	1 / 2	/ 1	/ 1	9 / 8
5		1800 / 17 / 10				3		/ 3				3		6 / 3
6		2600 / 12 / 8	1		1			1		1			2	6 / 0
7		3000 / 20 / 10	1	1	2	2	1	2		2	1	1		13 / 0
8		3500 / 25 / 14	2	1	1	2	2	2	2	2	2	2	2	20 / 0
9		1400 / 9 / 6	1		1		1		2		1		2	8 / 0
10		6000 / 12 / 8		1			1			1			1	4 / 0
11		1700 / 8 / 8	1	1		1		1 / 1	/ 1	1	/ 1	1	/ 1	6 / 4
12		2000 / 8 / 6				1	/ 1	1	/ 1	1	/ 1	1	/ 1	4 / 4
13		1000 / 7 / 7				1	/ 1	1	/ 1	1	/ 1	1	/ 1	4 / 4
14		800 / 10 / 5				1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	8 / 7
15		2000				1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	8 / 7
16		4500 / 11 / 13				4		4 / 4		4		6		14 / 8

MISSION MODEL OPTION 3S(CONT.)

		WEIGHT L / D	80	81	82	83	84	85	86	87	88	89	90	TOTALS
17		1000 / 12 | 10	1									2		3
18		2000 / 12 | 10					2							2
19		5500 / 20 | 12							1	2				3
20		900 / 17 | 10			2		2							4
21		1600 / 15 | 10												0
22		2500 / 16 | 12							1	1		1	1	4
23		5000 / 17 | 12							2					2
24		3300 / 17 | 12					2					2		4
SUB-TOTAL	NASA		14 / 0	16 / 0	12 / 0	23 / 0	17 / 14	22 / 20	16 / 13	24 / 10	16 / 10	26 / 9	15 / 14	201 / 90

MISSION MODEL OPTIONS (CONT.)

		WEIGHT L / D	80	81	82	83	84	85	86	87	88	89	90	TOTALS
25	2	690 / 12 / 5	2 /	2 /	2 /	2 /	2 / 2	2 / 2	2 / 2	2 / 2	2 / 2	2 / 2	2 / 2	22 / 14
26	3b	1570 / 15 / 5	1 /	/	1 /	1 /	1 / 1	/	1 / 1	1 / 1	1 / 1	/	1 / 1	8 / 5
27	15	1970 / 16 / 10	1 /	/	1 /	1 /	1 / 1	1 / 1	/	1 / 1	1 / 1	1 / 1	1 / 1	9 / 6
28	17	2200 / 12 / 10	/	/	/	2 /	2 /	/	1 /	/	1 /	1 / 2	1 / 2	8 / 4
29	12b	2400 / 20 / 10	/	/	/	/	/	/	/	/	/	/	/	0 / 0
30	6	3480 / 20 / 9	/	/	/	/	/	2 /	/	1 /	/	1 /	/	4 / 0
31	4a	3480 / 25 / 15	/	2 /	/	/	2 / 2	/	/	2 / 2	/	/	2 / 2	8 / 6
32	3a	1570 / 15 / 5	4 /	/	4 /	4 /	4 / 4	/	4 / 4	4 / 4	4 / 4	/	4 / 4	32 / 20
33	4b	3480 / 25 / 15	1 /	/	2 /	1 /	/	2 / 2	1 / 1	/	2 / 2	1 / 1	/	10 / 6
34	10	2745 / 20 / 9	/	1 /	/	1 /	1 /	/	1 /	/	1 /	/	/	2 / 3
35	8	2430 / 25 / 12.7	2 /	2 /	2 /	2 /	2 / 2	2 / 2	2 / 2	2 / 2	2 / 2	2 / 2	2 / 2	22 / 14
36	11a	850 / 9 / 6	3 /	/	/	3 /	/	/	/	/	3 /	/	/	9 / 0
37	11b	850 / 9 / 6	3 /	/	/	/	3 /	/	/	/	/	3 /	/	9 / 0
38	11c	850 / 9 / 6	3 /	/	/	/	/	3 /	/	/	/	/	3 /	9 / 0
39	5	735 / 3 / 5	/	/	/	3 /	3 /	/	3 /	3 /	/	3 /	3 /	18 / 0
40	16	2610 / 14.5 / 6.7	/	/	/	4 /	/	2 /	2 / 4	/	2 / 2	2 / 2	/	12 / 8
41	12a	6000 / 20 / 10	/	/	/	1 / 1	/	1 / 1	/	1 / 1	/	1 / 1	/	4 / 4
SUB. TOTAL	DOD		20 / 0	7 / 0	12 / 0	25 / 1	20 / 13	15 / 8	16 / 15	17 / 13	18 / 15	17 / 11	19 / 14	186 / 90
TOTAL			34 / 0	23 / 0	24 / 0	48 / 1	37 / 27	37 / 28	32 / 28	41 / 23	34 / 25	43 / 20	34 / 28	387 / 180

2.4 PROGRAMMATICS INPUT DATA

The following data was provided as a basic input to the programmatics studies. The first chart summarizes the total flights and hardware requirements. The second group of tables show the flight schedules and hardware requirements as a function of year. There are five tables in the group, an overall summary, NASA ETR, NASA WTR, DOD ETR and DOD WTR. These charts represent the data requested in NASA letter PD-TUG-P(028-74). The next chart shows the same flight requirements data in the format used by MDAC in the study. The final chart shows the usage of individual Tugs to accomplish the mission model. At the top of the chart, the number of flights per year is shown and the number of Tug expendable flights. The number of Tugs required were established by first determining the number of Tugs necessary to accomplish the 1990 requirements and working backward from that point.

CONFIGURATION OPTION 3S

	REQUIRED	ACCOMPLISHED
DEPLOYMENTS	387	355
RETRIEVALS	180	180
FLIGHT REQUIREMENTS (NASA/DOD)	INITIAL	FINAL
# ETR LAUNCHES	64 / 35	84 / 91
# WTR LAUNCH	4 / 6	33 / 15
# REFLIGHTS DUE TO LOSSES	1	3
FLIGHT COMPOSITION		
EXPENDABLES (E)	4	4
TUG WITH BURNER II (KS_1)	-	-
TUG WITH POLARIS (KS_2)	10	-
TUG (BASIC)	95	219
VEHICLE LOSSES/REFLIGHTS	1	3
	(110)	(226)
FLEET SIZE REQUIREMENTS		
FOR OPERATIONS	4	7
FOR RELIABILITY	1	3
TOTAL	5	10
REQUIREMENT AT IOC (MIN)	2	3
FLIGHTS PER ARTICLE	27.3	31.9

I 29.7

TURNAROUND CYCLE 32.3 DAYS LAUNCH TO LAUNCH (CALENDAR DAYS)

F L I G H T S C H E D U L E

TUG CONCEPT OPTION 3S

LAUNCH SITE ETR/WTR AGENCY NASA/DOD

COMPANY MDAC

	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
TUG (BASIC) **		3	21	22	37	(2) 40	34	(1) 35	(1) 39	34	(3) 35	(1) 36	(8) 336
AUXILIARY STAGE				(2)	(1)	(2)		(3)	(2)				(10)
DROP TANKS													0
(OTHER)	1*												1
SHUTTLE **	1*	3	21	22	37	40	34	35	39	34	35	36	336

() DENOTES NUMBER EXPENDED.

REMARKS: 33 payloads not accommodated due to Shuttle limits of 3 Tug flight in 1980 and 21 in 1981

* IVU test flights

** Includes reflights due to Tug reliability

F L I G H T S C H E D U L E

TUG CONCEPT OPTION 3S

LAUNCH SITE ETR AGENCY NASA

COMPANY MDAC

	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
TUG (BASIC)		3	14	12	15	(2) 18	15	(1) 14	(1) 16	12	(3) 16	(1) 13	(8) 148
AUXILIARY STAGE				(2)		(2)		(3)	(2)				(9)
DROP TANKS													0
(OTHER)	1*												1
SHUTTLE	1*	3	14	12	15	18	15	14	16	12	16	13	149

() DENOTES NUMBER EXPENDED.

REMARKS: 13 payloads not accommodated due to Shuttle limit on Tug flights

* IVU test flight

F L I G H T S C H E D U L E

TUG CONCEPT OPTION 3S

LAUNCH SITE ETR AGENCY DOD

COMPANY MDAC

	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
TUG (BASIC)			7	10	13	17	10	12	15	15	10	17	126
AUXILIARY STAGE					(1)								(1)
DROP TANKS													0
(OTHER)													0
SHUTTLE			7	10	13	17	10	12	15	15	10	17	126

() DENOTES NUMBER EXPENDED.

REMARKS: 20 DOD flights not accommodated due to Shuttle limit on Tug flights

F L I G H T S C H E D U L E

TUG CONCEPT OPTION 3S

LAUNCH SITE WTR AGENCY NASA

COMPANY MDAC

	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
TUG (BASIC)					4	4	6	4	6	4	5	4	37
AUXILIARY STAGE													0
DROP TANKS													0
(OTHER)													0
SHUTTLE					4	4	6	4	6	4	5	4	37

() DENOTES NUMBER EXPENDED.

REMARKS:

FLIGHT SCHEDULE

TUG CONCEPT OPTION 3S

LAUNCH SITE WTR AGENCY DOD

COMPANY MDAC

	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
TUG (BASIC)					4	1	2	5	2	2	4	1	21
AUXILIARY STAGE													0
DROP TANKS													0
(OTHER)													0
SHUTTLE					4	1	2	5	2	2	4	1	21

() DENOTES NUMBER EXPENDED.

REMARKS:

FLIGHT REQUIREMENTS

OPTION 3S

	80	81	82	83	84	85	86	87	88	89	90	TOTAL
ETR												
NASA	3	14	10	15	14	15	10	13	12	13	12	131
DOD	-	7	10	12	17	10	12	15	15	10	17	125
NASA EXPENDABLE	-	-	-	-	2	-	1	1	-	3	1	8
NASA KICK STAGE	-		2	-	2	-	3	2				9
DOD KICK STAGE	-			1								1
TOTAL	3	21	22	28	35	25	26	31	27	26	30	274
WTR												
NASA	-	-	-	4	4	6	4	6	4	5	4	37
DOD	-	-	-	4	1	2	5	2	2	4	1	21
TOTAL	0	0	0	8	5	8	9	8	6	9	5	58
REFLIGHTS / LOSSES				1		1			1		1	4

EQUAL USAGE SCHEDULE

OPTION 3S

	80	81	82	83	84	85	86	87	88	89	90	TOTAL
NUMBER OF FLIGHTS	3	21	22	36	40	33	35	39	33	35	35	332
NUMBER OF EXPENDED TUGS					2		1	1		3	1	8
TUG ID 1	2	9	7	10	3							31
2	1	8	9	10	3							31
3		4	2	10	3	2	3					24
4			4	6	2	1	4	6				23
5					10	9	8	3	2	2		34
6					10	9	4	6	2	2		33
7					9	9	7	4	3	1		33
8						3	6	7	6	5	6	33
9							3	10	5	6	9	33
10								3	10	9	10	32
11									5	10	10	25
REFLIGHTS / LOSSES				1		1			1		1	4